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CONTENTS

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THE PRIMARY CONCEPTS OF PHYSICS[1]

THE subject of the present address is one that does not often appear on a scientific program. Physicists are so busy in enlarging the structure of knowledge that few of them concern themselves with the consideration of the fundamental concepts of the science. Yet it is plainly true that if those fundamental or primary concepts are not clearly apprehended, or if there is doubt as to what they are, the whole structure of the science rests on an insecure basis. I propose to examine certain questions concerning these primary concepts, about which there has been and is much unsettled opinion. The discussion necessarily rests upon my own beliefs about them. In the nature of the case each man can speak positively about them for himself only. It would be very improper to dogmatize, and I shall accordingly have to crave your pardon for a frequent expression of my own opinion, believing it less objectionable to be egotistic than to be dogmatic.

The first question which I shall consider is that raised by the advocates of the dynamical definition of force, as to the order in which the concepts of force and mass come in thought when one is constructing the science of mechanics, or in other words, whether force or mass is the primary concept. It will be of service in the discussion if we consider briefly the way in which some of the great builders of the science of mechanics used these concepts.

[1] Presidential address delivered before the American Physical Society and Section B of the American Association for the Advancement of Science, at Washington, D. C., December 28, 1911.

There is no need of presenting the views of Archimedes or of Stevinus, whose work was exclusively in statics and who used the concept of force given us by our muscular or motor sense, and measured forces by weights. The views of Galileo, however, are interesting as showing how far one can go in dynamics without using the concept of mass.

Galileo examined the problem of the motion of a body acted on by a constant force. The only constant force of which he could dispose was the weight of a body, or a component of its weight, and he accordingly was limited in his studies to the examination of the laws of falling bodies. Owing to the relation of proportionality between the weight of a body and its mass, this limitation in a way simplified the problem, while at the same time it made it more difficult to develop a complete doctrine of force and motion. By the famous experiment at the Leaning Tower Galileo satisfied himself that he could study any falling body as a type, and that the conclusions which he would reach from that study would apply to all. His attention was therefore directed almost wholly to the consideration of the motion of the falling body, while the question of the relation between the motion and the weight of the body was disregarded. The result of this was that he developed the laws of linear motion with constant acceleration, and numerous consequences of those laws, chiefly relating to motion down inclined planes, with really wonderful completeness, and was led in the course of his thought to a full appreciation and statement of the principle of inertia, while yet he did not, in this part of his work, attain to any useful conception of the relation of force to mass. He makes it clear that the conception of force which is sufficient for his purposes is that with which he was familiar from his study of statics. He says, in speaking about the "tendency" of a body to fall down inclined planes of the same height, that "It is clear that the tendency of a body to fall is as great as the resistance or the least force which suffices to prevent its falling and to keep the body at rest." In fact Galileo thought of the weight of a body, with which he was familiar from common experience, as a force which moved the body, and assuming that the weight was unchanged during motion his experiments demonstrated what kind of motion such a constant force will set up and maintain.

In the very interesting discussion which Galileo gives of the forces exerted by the collision of one body against another, he approaches nearer than in other parts of his discourse to an appreciation of mass as a characteristic of a moving body. He speaks in one place of the falling body being a composite of weight and velocity, and his discussion of the impulse applied by such a falling body to another on which it falls shows that he was very near the concept of momentum; but there is no real precision in his statements.

We now turn to Newton to get the full doctrine of the relations of force and motion. It will be clear to any one who examines the introductory parts of the "Principia," that Newton did not undertake in that book to present a systematic treatise on dynamics. He merely blocks out a rough set of definitions and postulates, in a very uncritical way, which are sufficient to enable him to go on as promptly as possible to the real task which was before him. A striking instance of this uncritical attitude of mind is found in Definition I., in which he says, "Quantity of matter is its measure derived from its density and volume jointly." This quantity of matter thus defined he names

mass. Since we can only define density in terms of the concept of mass, it is surely uncritical to define mass in terms of density. In fact Newton on a later page uses the true definition when he says that bodies are of the same density if their *vires inertiæ* (that is, their masses) are proportional to their volumes.

The same sort of uncritical treatment appears in his presentation of the various types of force. He mentions first the *vis insita,* which he defines as the power of resisting, by which a body persists in its state of rest or of uniform motion. He says it differs in no respect, except in the way of conceiving of it, from the inertia of a mass.

Then comes *vis impressa,* the action (*actio*) exerted on a body to change its state of rest or of uniform motion. This is force in our ordinary sense. Newton says that it arises from a blow, from pressures or from centripetal force.

Vis centripeta is the force by which bodies are drawn or impelled from all directions toward any point as a center, or tend toward it in any way whatever. The force of gravitation and magnetic force are examples of this centripetal force. So also is the force by which a sling draws a stone in it toward the hand, which force Newton explains as arising from the stretching of the cord of the sling.

Newton then goes on to define the various measures or modes of giving quantitative expressions for centripetal forces. He first describes the *vis centripetæ quantitas absoluta* as the measure of it as greater or less by comparison with the efficiency of the cause which transmits it from the center through the surrounding region. Thus the magnetic force is greater in one magnet than in another, either because of the greater mass of the one or of the intensity of its power.

The *vis centripetæ quantitas acceleratrix* is the measure of it as proportional to the velocity which it generates in a given time. Thus the power (*virtus*) of a magnet is greater at lesser distances, and less at greater distances; gravitating force is greater in valleys, less on mountain peaks, and less still at greater distances from the earth. At equal distances, he says, this gravitating *vis acceleratrix* is the same everywhere, because all falling bodies are equally accelerated.

The *vis centripetæ quantitas motrix* is the measure of it as proportional to the momentum which it generates in a given time. This quantity is the center-seeking or tendency to the center of the whole body, and (as Newton says, with an evident appreciation that he is limiting the generality of his conception) is the weight of the body. It is always known by the force opposite to it, and equal to it, by which the fall of the body can be prevented.

Newton calls these quantities of force of the various sorts described by the shorter terms motive, accelerative and absolute forces, that is, he substitutes the general terms for the measured quantities of the forces which can be conceived only in those general terms. With this understanding he states that the *vis acceleratrix* is to the *vis motrix* as velocity is to momentum; for the quantity of motion (*momentum*) arises from the velocity and quantity of matter, and the *vis motrix* arises from the *vis acceleratrix* and the quantity of matter. For the sum of the actions of the *vis acceleratrix* upon the several particles of a body is the *vis motrix* of the whole body. Newton relates the *vis motrix* to a body as a striving of the whole body towards the center, made up of the striving of all its parts; the *vis acceleratrix* to the position of the body, as a certain efficiency, diffused from

the center through all places around it, for moving bodies which are in those places. The *vis acceleratrix* as thus described reminds us of the conception of the strength of a field of force.

This analysis of the concept of force surely does not promote a clear apprehension of it. The only one of the distinctions which have been made which seems to be worth retaining is that between the *vis impressa,* or action, and the *vis motrix impressa,* the one being force in its general or conceptual sense, the other the same force when given a measure or value. This distinction was clearly in Newton's mind and appears in the enunciation of the Laws of Motion. In the First Law the departure of a body from its state of rest or of uniform motion is ascribed to the *vis impressa;* that is, to force in general, without any specification as to its measure or even any declaration that it can be measured. In the Second Law the change of momentum is said to be proportional to the *vis motrix impressa;* that is, to force that is measured so that a proportionality to something else can be predicated of it. As has already been stated, Newton declared of this *vis motrix* in the special case of gravitation that it is known, or measured, by the force opposite to it and equal to it, by which the fall of the body, or, in the general case, the motion of the body, can be prevented. In the Third Law the force is called *actio.* This is the alternative word used in the definition of the *vis impressa,* as an equivalent for force in its general sense. The word in this sense is consistently used in the enunciation of the Third Law, in which forces are not considered as measured, but merely as compared by the condition of equality. From the examples of action and reaction which Newton gives (the finger pressed against a stone; the horse drawing a stone by a rope and drawn back equally toward the stone, because of the stretching of the rope and its exertion of equal forces at its two ends) it is plain that Newton conceived of forces in the way which is familiar to all of us, as the pushes and pulls which can be perceived by our motor sense, and as the causes of motions. He goes on to say that by these *actions* there are caused equal changes, not of velocity, but of momentum, so that the changes of velocity are inversely as the bodies (*corporibus*). In this way, without measuring forces, there is introduced the method of comparing masses.

It is difficult to perceive in these many definitions and declarations exactly what Newton's conception was of force, of the unit in which it is measured and of its relation to mass. After careful consideration of all that I can find in the "Principia" bearing on the question I am convinced that Newton viewed the concept of force as a primary one, or one directly given by intuition, and that he thought of the motions of bodies caused by these forces as connected quantitatively with them by the experimental relation embodied in the Second Law. Since Newton does not use a system of units, and states most of his laws and theorems in terms of proportions, the priority of force to mass, in the order of their apprehension, is not clearly presented.

In the matter of measuring a force he clearly asserts that a *vis motrix* is measured by the force which will counteract it and keep the body to which it is applied at rest, and the force thus used can hardly be other than a force measured statically; but his frequent insistence on the measure of *vis motrix* by the momentum which it causes shows that he had a conception also of the dynamical measure of force. He further supplies the measurement of mass as a fundamental quantity which is needed

to establish the dynamical measure of force by calling attention to the possibility of comparing masses by means of the velocities given them when acted upon by equal forces.

Lagrange in the "Mécanique Analytique" gives the most explicit expression to the definition of force in general which is the bugbear of so many thinkers, and which yet, after all, is the real expression of our belief about force, when he says:

We understand by force the cause, whatever it may be, which impresses or tends to impress a motion on a body to which we suppose it applied.

He goes on to say:

It should be measured by the quantity of motion impressed or ready to be impressed. In the condition of equilibrium, the force produces no actual effect; it produces only a simple tendency to motion; but it should be measured by the effect which it would produce if it were not restrained from acting.

Lagrange repeats this definition of the measure of force in the introduction to his "Dynamics," when he says that the product of the mass and the accelerating force (Newton's *vis acceleratrix*) or the acceleration, expresses the motive force (Newton's *vis motrix*). I can not find that Lagrange gives any definition of mass. From a statement in his treatment of centers of gravity it would seem that he considered the mass to be determined by its weight. He seems to endeavor to measure force in the purely dynamical way, without going into the matter as fully as he should for a complete elucidation of it.

Thomson and Tait say flatly that force is a direct object of sense, and define it as any cause which tends to alter a body's natural state of rest, or of uniform motion in a straight line. They assert that the measure of force is the quantity of motion which it produces per unit of time. They give no other definition of mass than the one given by Newton.

From the account which has been given of the views held or expressed by some of the great leaders of thought in matters of dynamics it is clear that very indefinite notions existed in their minds with respect not only to the proper definition of force, but even with respect to the proper measure of force, which is fundamental and necessary in the development of dynamics. The acute and valuable criticism by Mach of this fundamental notion is so colored in its expression by Mach's favorite principle of economy that it is not altogether satisfactory, and I accordingly shall attempt to present what seems to me the proper order of thought on this matter. Similar statements have been many times made, but there is still no general consent in the minds of physicists as to the statement which should be acceptable to every one.

There is no doubt that the dynamical *measure* of force is the correct one to use in building up a system of units. The point of difference on which dispute arises is the order of precedence of the two concepts force and mass in the establishment of this definition. It is not uncommon to have force defined as the product of mass by acceleration, or of mass by the acceleration which the mass would have if it were free to move. In this definition mass is the primary concept. Now, as I view the question, force is the primary concept, a direct object of sense, and we know it to be a cause of motion, or of the distortion of a body to which it is applied and which counteracts it when the distortion has reached a certain limit. In particular we know it as counteracting, or as being counteracted by, the weight of a body. This conception of force is adequate for the development of statics, in which we treat the principles of statics as statements of laws which are derived from experiment and confirmed by the proof that they are

mutually consistent. Galileo's experiments on falling bodies are then the direct experimental proof in a limited case of the proportionality between the force which acts on a body, measured at any one place by a weight, and the acceleration imparted to the body. Newton's Second Law is a statement of Galileo's discovery, with this addition, that the acceleration imparted by a force is not the same for all bodies, but depends upon a certain characteristic of the body. This characteristic, the mass of the body, first calls for recognition at this point. In the view I have taken the mass is the factor of proportion between the force which acts on a body and the acceleration which it imparts to the body. Since we can measure forces by comparison with a standard force, we can also measure masses by the aid of properly instituted experiments. Whether we measure masses in this way or not, and it turns out to be not a satisfactory way to do it, we at least get from this relation between force, of which we have a concept, and motion, of which we have a concept, an adequate working concept of mass. Force is the primary concept and mass is a derived concept.

Now owing to the permanency of masses of matter it is convenient to construct our system of units with a mass as one of the fundamental units. We are able to do this and to compare one mass with another chosen as standard, without going through the operation of measuring forces, by utilizing the principle embodied in Newton's Third Law. This law asserts that bodies which interact, that is, which exert forces on each other, exert equal forces, and thus, if the bodies are free to move, their acceleration will be inversely as their masses. By observation of the accelerations of two mutually interacting bodies we may thus compare their masses, and so construct a set or scale of masses, and use these masses and their accelerations to measure forces. Thus while the concept of force is primary in the order of thought, we may make the unit of mass fundamental in the development of a system of units.

The point upon which I wish to insist is that both reason and the history of mechanics show that the foundation of the science is the purely intuitional concept of force which is shared by every intelligent being, and that this intuitional concept is not only accurate so far as it goes, but adequate to serve as the foundation of a great science. No use of the concept of force in the theories of physics has ever violated in any particular this original and intuitional concept of it. Even the brilliant endeavor of Hertz to found all the principles of dynamics upon the three concepts of time, space and mass can not escape the criticism that the concept of mass is meaningless to us unless it is given to us by our experience of the inertia of matter when we exert force upon it. Once that concept is attained it may be used, as Hertz so beautifully used it, in the logical upbuilding of a system of dynamics. Perhaps my contention will be made clearer if we consider briefly the question whether it would be possible for us to construct our present system of dynamics if we were disembodied spirits, gifted with the means of observing spaces, times and colors, but without the sensation of force. We could see colored volumes, sometimes moving with constant velocity, sometimes with varying velocity, and we could ascribe the changing velocity to the action of a force. We further could connect the force with the moving volume by setting it equal to the acceleration multiplied by some factor which we might name the mass. This equation would contain two unknown and

unmeasured quantities, and would mean nothing unless we could go further. Now the advocates of the purely dynamical definition of the concept of force say that we can go further, by observing the mutual accelerations of two bodies and using these to obtain the ratio of their masses. If this can be done the matter is settled. But could it be done by the disembodied spirit? In our use of the mutual accelerations of two bodies to get their masses we must explicitly state that the bodies are arranged so as to interact (that is, to exert force on each other), and unless that condition is established the mutual accelerations of two bodies, however often repeated, can tell us nothing about their masses. A man at a station might observe two trains leaving the station in opposite directions with the same accelerations every day for ten years, and yet he could not compare their masses by any such observations. Eyes and mind only will not do it. To get the measure of mass we must start with the intuitional knowledge of force, and use it in the experiments by which we first define and then measure mass.

I now come to a much more difficult part of my subject, the consideration of the other primary concepts of space and time. Not many years ago we should have been willing to pass them over with a mere mention, admitting the impossibility of giving a definition or even an intelligible description of either of them, admitting the impossibility of determining an absolute or fixed point in space, or an absolute instant of time, but still asserting that we knew something about them both of which we were sure. At present we are driven by the development of the principle of relativity to examine anew the foundations of our thought in respect to these two primary concepts.

I suppose that the old ideas about space and time that have been of service to physicists since the beginning of the science are summed up as well as anywhere in Newton's words:

Absolute and real time, the time of the mathematician, flows on equably, having no relation in itself or its nature to any external object. It is also called duration. Relative, apparent time, the time of common life, is an external measure of any duration cognized by the senses, by means of motion. It is commonly used in place of real time.

Absolute space, having no relation in its nature to any external object, always remains alike everywhere and immovable. Relative space is the measure of this space, or any movable dimension, recognized by our senses as limited by its situation with respect to bodies. This is commonly thought of as equivalent to absolute space.

These definitions have been often justly criticized for the emphasis laid on the unfruitful ideas of absolute time and space. Perhaps the criticism has fallen rather upon Newton's subsequent expansion of his thought on these ideas. But do they not contain in the first place the conceptions of time and space which have been uniquely useful up to this time in physics, and in the second place, do they not contain what each one of us really thinks about time and space when he makes an honest examination of his knowledge? The essential feature of both these descriptions for our present purpose is Newton's declaration, both as to time and space, considered as species and not as magnitudes, that they are in themselves and in their nature without relation to any external object. It is this statement which is contradicted by some of the enunciations of the principle of relativity.

It is not necessary for me to give an account of the genesis of the principle of relativity. It may fairly be said to be based on the necessity of explaining the negative result of the famous experiment of Michelson and Morley, and on the con-

venience of being able to apply Maxwell's equations of the electromagnetic field without change of form to a system referred to moving axes. It is not needed to explain many of the remarkable results obtained by Fizeau, by Mascart and by Brace, in the field of experimental optics, which to a first inspection seem to show that the earth and the medium around it through which light passes are relatively at rest, but which a closer study by Lorentz and others shows may be compatible with a reasonable theory of the structure of matter and the hypothesis that the luminiferous medium is at rest. It is also not needed to explain the dependence of the path of an electron in a field of crossed electric and magnetic forces upon its velocity, as exhibited in the beautiful experiments of Kauffmann and of Bucherer, for other theories in which the principle is not used lead to expressions for the path which, for the present at least, are in as good accord with observation as those which are deduced by the aid of the principle of relativity.

There are two ways of presenting the principle of relativity. In the first way the principle is stated as a direct inductive conclusion from the experiment of Michelson and Morley, and asserts that so far as a conclusion can be drawn from that experiment and the others which have been tried to test the matter, there is no way by which the relative motion of the earth and the luminiferous medium can be determined from observations made on the passage of light when the source of light and the observer are moving with the earth. As thus presented the principle holds out as the object of future study the construction of a suitable theory of the structure of matter and of the luminiferous medium to account for this fundamental experiment as well as for all other known truths in the domains of light and electricity. If this theory is expressed in terms of the Lorentz transformation, and thus shows a dependence of the measure of time and the measure of length upon the velocity of the system in which the observer is placed, it will further be the object of inquiry to construct a theory of the relations between the material of the system and the luminiferous medium which will account for the change in the units of length and in the motions of bodies by which the unit of time is determined. When I say to account for, I mean to describe in terms of force, time and space, as we conceive those notions in our every-day experience, and as we use them in our ordinary physical work, so that the description when apprehended will be reduced to the lowest terms in which our thought about the universe can be expressed. Such a description is, as I view it, a real explanation, and surely it is not yet time to say that such an explanation is impossible.

The other way of presenting the principle of relativity consists in laying down as a fundamental postulate a general proposition expressing the hopelessness of any attempt to settle the question raised by the experiment of Michelson and Morley by any theory of the structure of the universe. This postulate sometimes assumes a formidable aspect, and involves more than the mere postulate of relativity. Thus Laue says:

> The principle of relativity asserts that from the totality of natural phenomena we may, with continually increasing approximation, determine a system of reference, x, y, z, t, in which the laws of nature hold in a definite and mathematically simple form. This system of reference is by no means uniquely determined by the phenomena. There is rather a triple infinity of equally admissible systems, which move relatively to one another with uniform velocities.

The feature of this enunciation of the principle to which I referred as an addi-

tion to the principle is the expressed condition that in the system of reference the laws of nature hold in a definite and mathematically simple form. There is no warrant in the past history of physics for the adoption of such a postulate as that. Surely the history of the discovery of the so-called secondary laws of physics, such as Boyle's law, the laws of friction, the laws of polarization and of absorption of light, the laws of magnetization, and many others, will bear out the statement that in very many cases the first enunciation of the law is in a definite and mathematically simple form, and that further knowledge shows that this form is only a first approximation to the truth. Even in the case of such laws as the law of gravitation, or of electrical attraction and repulsion from which we have not yet detected any deviation, does any one dare to say that they are universally true for all bodies and at all distances? Can we even feel sure that Maxwell's electromagnetic equations hold true with absolute exactness? They need supplementing when they are applied to material bodies. Can we be sure that they hold without modification, in rapidly moving bodies, or at extremely minute distances in free space. Or, from another point of view, admitting that the object of physical study is to reduce the description of natural phenomena to a set of simple laws, have we a right to assume that, in our analysis of the structure of matter and of the luminiferous medium, we have as yet reached the ultimate model in which such simple laws will be operative? The answer to this question must be a negative one. Yet it is surely true that if it were not for this demand of simplicity, immediately attainable and at present expressed in the electromagnetic equations, the chief incentive to the development of the theory of relativity would be wanting.

But this is not the heart of the matter. With the principle of relativity as a basal postulate, not expressing our present inability, but rather the hopelessness of any attempt to obtain ability, a complete description has been given of the phenomena now known to physicists, at least in the domains of mechanics, light and electricity. The difficulty which I find in accepting the principle, with the universality that is predicated of it, is that it does so much more than this.

The theories of J. J. Thomson and of Lorentz made physicists familiar with the notion of electrical mass, exhibited by the variability of the mass of a moving charged body, or by the apparent variable inertia of a moving charge expressed as a function of its velocity, and further with the notion that as the velocity of the charge approaches the velocity of light the magnitude of the electrical mass approaches infinity, so that the velocity of an electrical charge, of an electron, and therefore presumably of matter, if it is entirely electrical in its structure, can never surpass the velocity of light. In these theories this remarkable conclusion was explained by the interaction between the moving charge and the ether. In the theory of relativity the same conclusion is reached as the consequence of a purely kinematical theorem, giving the rule for the addition of velocities, and not only does it hold for real moving charges, but for any action whatever which is conceivably transmitted through space. In particular this finite velocity of transmission must be ascribed to gravitational action. Now the Newtonian theory of gravitation assumes a practically infinite velocity of transmission of gravitational action, and astronomical observations have never given any warrant for the belief that its velocity of transmission is even of the order of mag-

nitude of the velocity of light. The attempt has been made to reconcile the theory of relativity with the observed motions of the planets by the adoption of an arbitrarily chosen term in the formula for the force on a planet to represent what is equivalent to a counteracting force to annul the tangential acceleration which would arise from the finite rate of transmission of gravitational force. This is manifestly an artifice and not an explanation. If the principle of relativity is of universal application, it should not need the introduction of such an artifice to help it out in the solution of one of the classical problems of physics.

Further, the principle of relativity in this metaphysical form professes to be able to abandon the hypothesis of an ether. All the necessary descriptions of the crucial experiments in optics and electricity by which the theories of the universe are now being tested can be given without the use of that hypothesis. Indeed the principle asserts our inability even to determine any one frame of reference that can be distinguished from another, or, what means the same thing, to detect any relative motion of the earth and the ether, and so to ascribe to the ether any sort of motion; from which it is concluded that the philosophical course is to abandon the concept of the ether altogether. This question will be amply and ably discussed this morning, but I may venture to say that in my opinion the abandonment of the hypothesis of an ether at the present time is a great and serious retrograde step in the development of speculative physics. The principle of relativity accounts for the negative result of the experiment of Michelson and Morley, but without an ether how do we account for the interference phenomena which made that experiment possible? There are only two ways yet thought of to account for the passage of light through space. Are the supporters of the theory of relativity going to return to the corpuscles of Newton? Are they willing to explain the colors of thin plates by invoking "the fits of easy reflection and of easy transmission?" Are they satisfied to say about diffraction that the corpuscles near an obstacle "move backwards and forwards with a motion like that of an eel"? How are they going to explain the plain facts of optics? Presumably they are postponing this necessary business until the consequences of the principle of relativity have been worked out. Perhaps there is some other conceivable mode of connection between bodies, by means of which periodic disturbances can be transmitted. We may imagine a sort of tentacular ether stretching like strings from electron to electron, serving as physical lines of force, and transmitting waves as a vibrating string does. Such a luminiferous medium would not meet the postulate of simplicity, but it conceivably might work. But whatever the properties of the medium may be, there is choice only between corpuscles and a medium, and I submit that it is incumbent upon the advocates of the new views to propose and develop an explanation of the transmission of light and of the phenomena which have been interpreted for so long as demonstrating its periodicity. Otherwise they are asking us to abandon what has furnished a sound basis for the interpretation of phenomena and for constructive work in order to preserve the universality of a metaphysical postulate.

The electromagnetic equations, too, the retention of which in their present simple form is the *sine qua non* of the promoters of the principle of relativity, were not only developed by the conscious use of the hypothesis of a medium in which the electric and magnetic forces exist, but can be inter-

preted intelligibly only in terms of some such medium. The abandonment of this hypothesis reminds one of Baron Münchausen's feat performed while he was making his escape from prison. Since your historical reading may not have extended to the autobiography of this famous man, I may be permitted to relate that the Baron was letting himself down from the windows of a high tower by a rope, and when he reached the end of it he found that he still had a long distance to go. The last part of the descent was particularly difficult, so to get rope enough he ingeniously spliced on an additional piece, which he obtained by cutting off the part above him.

The principle of relativity in its metaphysical form ignores the accelerations of bodies. It is true that the experimental results to which the principle has been applied with such success are such that the study of acceleration in terms of the theory of relativity has not become necessary. But is it not reasonable to suppose that when suitable experiments have been invented and tried to test the effect of the acceleration of a system on the progress of light in it, it may be found that an effect can be detected? Some effect may be detected, for example, due to the rotation of a body. I have never been able to perceive any sound objection to Newton's assertion that we have evidence of absolute rotation by the observation of centrifugal force, and if a fixed direction of an axis and an absolute velocity of rotation can be determined in a mechanical system when accelerations are taken into consideration, why should the principle of relativity be treated as having universal validity?

But, after all, these questions raised by the development of the principle of relativity are of secondary importance. The central question is whether or not this principle can ever furnish a satisfactory explanation of natural phenomena. The formulas derived from it are evidently merely descriptive. This may be said with truth about all the formulas in which the general theories of physics have been embodied. Kirchhoff designates, as the task of the science of mechanics, the description of the motions which occur in nature completely and in the simplest possible way. This assertion that the task of the theoretical physicist is done when he has reduced the phenomena with which he is dealing to a set of formulas, or, as we may say, when he has constructed an ideal model which will reproduce the phenomena, is one to which we would all assent in general. At the same time most of us would reserve the right to criticize each model thus presented, and to give to one or the other a preference based on considerations which are not necessarily limited to the simplicity of the model or to the completeness with which it reproduces the phenomena. Surely an additional test of the value of the model will be the intelligibility of the elements of which it is composed.

This last test has been generally met in the models which have been proposed as descriptions of natural phenomena. We can understand from what we see and feel what is meant by the motions of elastic spheres, and the model which uses them to represent the behavior of a gas is not only competent to reproduce the behavior of a gas, but is intelligible in the elements of which it is composed. The model of the elastic solid ether, incomplete and objectionable as it became when the subject of optics was enlarged and developed, was intelligible in its elements. The model of electromagnetic operations embodied in Maxwell's formulas is also one which is thus intelligible in its elements. When I say this I do not mean that we know all

about electric and magnetic forces, but I mean that we do know enough about such forces to have a clear notion of their variation in space and their variation in time.

This feature of the ideal model or description seems to me to be necessary in order to make the model acceptable as the ultimate or last attainable explanation of phenomena. The elements of which the model is constructed must be of types which are immediately perceived by the senses and which are accepted by everybody as the ultimate data of consciousness. It is only out of such elements that an explanation, in distinction from a mere barren set of formulas, can be constructed. A description of phenomena in terms of four dimensions in space would be unsatisfactory to me as an explanation, because by no stretch of my imagination can I make myself believe in the reality of a fourth dimension. The description of phenomena in terms of a time which is a function of the velocity of the body on which I reside will be, I fear, equally unsatisfactory to me, because, try I ever so hard, I can not make myself realize that such a time is conceivable.

Tried by this test, I feel that the principle of relativity does not speak the final word in the discussion about the structure of the universe. The formulas which flow from it may be in complete accord with all discovered truth, but they are expressed in terms which themselves are not in harmony with my ultimate notions about space and time. That this is true is so evident that it is generally admitted. Some writers say that we should not let this circumstance disturb us, because Kant has said that time and space are mere forms of perception, a scheme in which we must arrange occurrences so that they may acquire objective significance. I do not altogether understand what Kant meant by this, but I am sure he did not mean that by the exercise of our wills we can violently eject from our consciousness the notions of space and time which we have in common with the whole race of man, and impose on ourselves other and radically different notions. Planck compares our position before the new notions presented by the theory of relativity to the position of the medieval peoples before the notion of the antipodes. It seems to me that there is no real similarity between the two positions. Many men in the Middle Ages believed that there were no antipodes, but their belief was based on reasons, and so far were they from being unable to conceive of antipodes and to believe in their existence, that there were men who actually maintained their existence, and were pursued therefor as heretics. I do not believe that there is any man now living who can assert with truth that he can conceive a time which is a function of velocity or is willing to go to the stake for the conviction that his "now" is another man's "future" or still another man's "past."

One of the members of this society, recognizing our present inability to conceive of relative time, and conceiving our intuitions of space and time to be the result of heredity operating through many generations of men who lacked the light of relativity, once proposed to me that every one who could get even a glimmer of the notion of relative time should persistently exercise his mind therein and teach it to his students, in the hope that in a few generations the notion would emerge with the force of an intuition. It would not be fair to leave the impression that he was solemnly serious when he made this suggestion. When Matthew Arnold was asked to endure the transliteration of Greek names into English in order that the new forms might become familiar to future scholars,

he answered that he was not willing to spend his days in a wilderness of pedantry that his children might enjoy an orthographical Canaan; and *mutatis mutandis* the same answer may be given in this case. But a more pertinent answer is, to my mind, this, that the attempt to reorganize the perceptions of the human mind in respect to space and time is doomed to failure. "Which of you by taking thought can add one cubit unto his stature?" I believe that these ultimate perceptions are the same for all men now, have been the same for all men in the past, and will be the same for all men in the future. I believe, further, that this is true because the universe has a real existence apart from our perceptions of it, and that through its relations to our minds it imposes upon us certain common elementary notions which are true and shared by everybody.

Therefore, from my point of view, I can not see in the principle of relativity the ultimate solution of the problem of the universe. A solution to be really serviceable must be intelligible to everybody, to the common man as well as to the trained scholar. All previous physical theories have been thus intelligible. Can we venture to believe that the new space and time introduced by the principle of relativity are either thus intelligible now or will become so hereafter? A theory becomes intelligible when it is expressed in terms of the primary concepts of force, space and time, as they are understood by the whole race of man. When a physical law is expressed in terms of those concepts we feel that we have a reason for it, we rest intellectually satisfied on the ultimate basis of immediate knowledge. Have we not a right to ask of those leaders of thought to whom we owe the development of the theory of relativity, that they recognize the limited and partial applicability of that theory and its inability to describe the universe in intelligible terms, and to exhort them to pursue their brilliant course until they succeed in explaining the principle of relativity by reducing it to a mode of action expressed in terms of the primary concepts of physics?

WILLIAM FRANCIS MAGIE
PRINCETON UNIVERSITY

THE MOVEMENT FOR SCIENTIFIC INTERNATIONALISM AT THE HAGUE

PEDAGOGY lays ever greater emphasis on positive suggestion of the things that are good to do, rather than on negative prohibition of what is undesirable. The peace movement, as one of the biggest educational problems now in hand, is applying this principle in many ways. Everything which makes more evident the common interests of mankind tends toward peace as it awakens the larger loyalties which more and more take the place of primitive Chauvinism. The things which are specifically national are few and the things which are coextensive with human thought and human effort, many. If a realization of this fact were deep enough and wide enough men would altogether refuse to allow their interest and their public moneys to be diverted from the great common task, the advance of knowledge and its application to human welfare, by the little jealousies between groups which happen to live under different political organizations. The Foundation for the Promotion of Internationalism at The Hague has for its purpose the furthering of those movements for intellectual and social progress which are international in scope, and by so doing it plays an important part in the growth of the spirit of world peace.

It is obvious that, if such ends are to be realized, the efforts made must tend to meet practical needs in various fields of thought and action and not merely express a vague aspiration toward abstract ends. The Foundation for the Promotion of Internationalism has therefore addressed itself to a systematic study of the various movements for inter-

nationalism and the needs which they indicate, the shortcomings of previous efforts and the most profitable lines for future advancement. Two monographs already prepared by Dr. P. H. Eijkman, Director of the Preliminary Office of the Foundation, deal with "L'Internationalisme Medical," 1910, and "L'Internationalisme Scientifique," 1911, and these volumes furnish a most impressive argument for the "organization of organizations" contemplated by the foundation.

The advantages to be gained by international organization may be best estimated perhaps by considering what national associations have already accomplished within their more limited territory. The services of the American Association for the Advancement of Science, the American Medical Association and the American Public Health Association and the American Chemical Society, for example, have been notable forces in their respective fields. Such organizations serve a twofold purpose. On the one hand, by their meetings and by their publications they serve as a medium of communication between their members, bringing the experience of each to the service of all. On the other hand, they serve as an authoritative medium of communication with the public, furthering as occasion demands a popular knowledge of the subjects with which they deal, and presenting a united influence upon official action to which their sciences are, or should be, related.

The transition from such national societies to international ones has been a natural and inevitable one, and has led to the formation of world organizations and world congresses, in profusion. How numerous such international efforts have been no one probably realized until Dr. Eijkman brought them together (for medicine and for pure science and letters) in the two volumes to which reference has been made. In the second of his books he lists over 600 international organizations and Professor Baskerville in an article on International Congresses in SCIENCE for November 11, 1910, catalogues 125 international congresses in science alone. These diverse international societies and congresses have proved of great importance; but they fall far short of the needs, for a world organization of intellectual effort. For the most part there has been no permanent organization to connect adequately the work of successive congresses and there has nowhere been a due correlation between the work of different groups, drawn together often by some local or temporary need. There is duplication, on the one hand, with unoccupied fields on the other, and while certain congresses have been markedly successful, others have fallen short of reasonable expectation. All these defects must be to some extent inherent in human undertakings; but they could surely be minimized by a central bureau which could correlate the more important lines of intellectual activity and give to each of them a permanent organization.

Such an idea led to the establishment of the Office Centrale des Institutions internationales at Brussels and to the calling together under its auspices, of the Congres mondial des Associations internationales in 1910. The field covered by this congress was so wide, however, that it could hardly hope to accomplish very much along specific lines. Every sort of international movement was included in the Brussels program and it is a somewhat large task to organize all at once the whole field of international life. The Foundation for the Promotion of Internationalism at the Hague has wisely determined to address itself rather to the specific problems presented by certain definite branches of science rather than to any all-embracing programs.

The most promising line of advance, as Dr. Eijkman has well shown in his volume on "L'internationalisme scientifique," has been marked out by the development of permanent organizations, of international scope, but dealing with related problems and representing naturally cooperative groups. Of these the Association internationale des Academies furnishes the most notable example. Representing as it does twenty-two academies in the leading scientific nations of the world, it occupies an authoritative position in pure science and letters and it has undertaken since its first general meeting in 1901 a series of

practical tasks of the first magnitude, tasks which only a world organization could successfully undertake. Among them may be mentioned the publication of a complete edition of the works of Leibnitz, an encyclopedia of Islam, a critical edition of the Mahabharata, an annual publication of physical and chemical constants, the measurement of an arc of the thirtieth meridian, the organization of a central committee for the study of the brain and the development of the work of the Institut Marey and the laboratories on Mont Rose.

The International Association of Academies still lacks, however, a permanent home and an opportunity for correlating its efforts with those of similar organizations dealing with related work in various branches of applied science and art. This is the dream of the Foundation for the Promotion of Internationalism, a series of such strong international bodies representing the most important fields of intellectual endeavor, all with permanent bureaus at the Hague, and all working together on definitely correlated lines for the organization of human effort.

This is not merely a dream. Two such bureaus are already well under way and a third has just come into existence. The Bureau de la Commission permanente des Congres internationaux de Medecine was established at the 16th International Congress of Medicine at Budapest in 1909. Its functions include the general planning of congresses and the arbitration of disputed points, the designation of place of meeting, standards for membership, official languages, number and scope of sections and number of papers presented, scrutiny of the votes passed by sections, correspondence with other international congresses and societies in order to avoid conflict, the promotion of the study of medical questions requiring international cooperation and the institution of commissions for such purposes. At the Brussels meeting of the International Congress of Pharmacy in 1910, a similar organization was effected in the shape of a Bureau permanent de la Federation internationale de Pharmacie, also with offices at the Hague. The objects of this international federation are fully and definitely outlined and include the collection and dissemination of data in regard to scientific and practical pharmacy, the promotion of uniformity in educational requirements for pharmacists, the study and dissemination of information in regard to laws relating to pharmacy, the organization of international pharmaceutical congresses, collaboration with other international societies and many more. The third permanent international bureau at the Hague has just been established in the form of a Bureau permanent de l'Institut international de Statistique.

The Foundation for the Promotion of Internationalism, which was an active agent in the creation of these three bureaus, is anxious to continue its admirable work by the development of similar permanent organizations in related fields. Dr. Eijkman, its director, is at present in America with a view to arousing interest in three such undertakings which seem of immediate practical importance. The first of these is a permanent international bureau for pure science and letters which would seem to be a natural development of the International Association of Academies and might properly be undertaken under its auspices. The second is a similar bureau for hygiene (public health would be a far better term, but the word hygiene is probably too firmly entrenched in European parlance to be dislodged). Public health has far outgrown the bounds of medicine, since it includes specialists in engineering, biology, bacteriology, chemistry and statistics, as well as in medical science; and the Permanent Commission of International Medical Congresses at its first meeting in London endorsed the plan for a bureau of hygiene at the Hague. No field of scientific effort has more manifold international relations than public health and it is to be hoped that the International Congress of Hygiene and Demography may take definite steps toward this end at its meeting in Washington next fall. Finally, the Foundation for Internationalism hopes to secure the establishment of a third new bureau

dealing with technology; and the International Congress of Applied Chemistry which meets in Washington and New York in September might well institute a movement toward this end.

These plans for international scientific bureaus at the Hague have the cordial support of the government of the Netherlands which is financing the bureaus so far created and the cooperation of the leading European men of science. The Preliminary World Committee includes in a list of several hundred the names of Arrhenius, v. Babes, Bang, Bertillon, Ehrlich, E. Fischer, Flügge, R. Hertwig, van't Hoff, Landouzy, Leduc, Lockyer, Madsen, Metchnikoff, Oppenheim, Ostwald, Ramsay, Richet, Roux, Rubner, Salomansen, Sanarelli, Schuster, Scott-Sherrington and Waldeyer. In the United States he has already secured the adhesion of J. McKeen Cattell, Harvey Cushing, George Dock, E. Dana Durrand, John S. Fulton, George E. Hale, W. G. MacCallum, S. N. D. North, Henry Fairfield Osborn, E. C. Pickering, Ira Remsen, Charles D. Walcott, W. H. Welch and many others.

These efforts deserve the cordial support of American men of science, both for the practical service which the proposed permanent international bureaus would render to their respective sciences and arts and for their beneficent effect upon the movement for peace and for the progressive organization of the world.

C.-E. A. Winslow

American Museum of Natural History,
New York

SCIENTIFIC NOTES AND NEWS

Dr. Simon Flexner, director of the Rockefeller Institute for Medical Research, has sailed for Europe to give the Harben lectures before the London Institute of Public Health and the Cameron lecture at Edinburgh University.

On account of illness Professor Josiah Royce, of Harvard University, has been compelled to give up the course of Bross lectures on "The Sources of Religious Insight" and has been given leave of absence for the present academic year.

Professor W. A. Noyes, director of the chemical laboratories of the University of Illinois, has been granted leave of absence to go to Berlin as the representative of the American Chemical Society at the International Conference of Chemical Societies.

The directors of the Bache Fund of the National Academy of Sciences have voted a grant of $500 to Professor M. A. Rosanoff, of Clark University, in aid of his research on the dynamics of sugar inversion.

The Sarah Berliner research fellowship for women has been awarded to Miss Marie Gertrude Rand, of Brooklyn, a doctor of philosophy of Bryn Mawr College, for her work on the psychology of vision.

Dr. Gustav Hellmann, director of the Meteorological Bureau in Berlin, has been elected a member of the Berlin Academy of Sciences.

Sir Edwin Ray Lankester has been elected an honorary student of Christ Church, Oxford.

Dr. Charles Chilton, professor of biology at Canterbury College, New Zealand, has been granted leave of absence for 1912, and will spend the year in Europe visiting biological laboratories and stations.

Professor Frederic B. Loomis, of Amherst College, Waldom Shumway, '11, and Philip L. Turner, '12, members of the Amherst biological expedition to South America, arrived at Amherst last week from Buenos Aires. The party left this country last July and has been occupied in the exploration of practically unknown territory in southern Patagonia. A large collection of fossil remains has been obtained.

Professor T. A. Jaggar, Jr., of the Massachusetts Institute of Technology, has been granted leave of absence for the remainder of the year that he may perfect the plans for the Vulcanic Laboratory at Halemaumau in the Hawaiian Islands. This observatory has been

in the charge of Professor Perret during the past summer.

PROFESSOR F. O. GROVER, head of the department of botany of Oberlin College, devoted a portion of the summer recess to work on Monhegan Island, Maine, where he discovered several unknown plants and extended the known distribution of other species. His most important find was a specimen of *Carex crinita portereii,* which has not been seen by botanists since its discovery at Moosehead Lake in the early seventies.

PROFESSOR ERICH VON DRYGALSKI, of Munich, leader of the German South Polar Expedition, has been entrusted by the Prussian Academy of Sciences with the continuation of the explorations in China begun by the late Professor Ferd. von Richthoven.

DR. MARCUS BENJAMIN, of the U. S. National Museum, has been appointed by the president to serve on the Assay Commission that meets in Philadelphia on February 14.

UNDER the auspices of the College of Sciences, a series of lectures will be given at the University of Illinois by Professor W. Johannsen, of the University of Copenhagen, on "Modern Problems of Heredity." These lectures will be given from February 26 to March 2, 1912. The first lecture at the University of Illinois will be an introductory one on such topics as "The Primitive Conception of Heredity." "'Transmission' of Personal Characters," etc. The second on "The Principle of Pure Lines." The third lecture, "Mendelism." The fourth, "Complications and Exceptions." The fifth, "Mutations." The sixth lecture, "Continuity or Discontinuity in Evolution." From March 4 to 10 a series of five or six lectures will be given, also under the auspices of the College of Science, by Professor W. Kukenthal, of the University of Breslau.

ON January 16 Professor W. Bateson began a course of six lectures at the Royal Institution on "The Study of Genetics."

PROFESSOR V. VOLTERRA, of the University of Rome, is giving a series of lectures at the University of Paris on the extension of the theory of functions, the integro-differential equations and integral equations, with applications.

THE Moissan memorial lecture before the London Chemical Society will be delivered by Sir William Ramsay, on February 29.

PROFESSOR W. JOHANNSEN, of the University of Copenhagen, gave an address on "Problems of Heredity" before the Minnesota chapter of Sigma Xi on the evening of February 10.

PROFESSOR A. V. BLEININGER, of the University of Illinois, delivered a series of lectures on the theory and technology of clays and other silicates, before the classes in economic geology of the University of Chicago, January 22–27.

DR. W. A. HEIDEL, professor of Greek at Wesleyan University, gave an address on "The Beginnings of Science" before the Middletown (Conn.) Scientific Association on February 13.

EDWARD M. EAST, assistant professor of experimental plant morphology, Bussey Institute, Harvard University, lectured at Trinity College on the evening of February 16 on "Influences of Recent Advances in Biology in the Art of Plant Breeding."

PROFESSOR M. A. ROSANOFF, of Clark University, lectured on February 1 and 2 before the industrial research fellows at the University of Pittsburgh on "The Partial Vapor Pressures of Liquid Mixtures."

MR. HAROLD PARKER, on February 9, delivered a lecture on "Contracts and Specifications" before the graduate students in highway engineering at Columbia University.

THE senior class of the Colorado School of Mines has recently been given addresses by professional men of Denver. Mr. Frank E. Shepard, president of the Denver Engineering Works Co., spoke on "Modern Mill Practise" and on "Modern Mill Plant Design"; Mr. John C. Traylor, of the Traylor Engineering Works, spoke on "Jigging," and Mr. W. H. Trask, consulting engineer for the Cen-

tral Colorado Power Co., spoke on "Modern Hoisting Installations."

PROFESSOR W. E. CASTLE has returned from the expedition which he recently made to Peru under the auspices of the Carnegie Institution of Washington, having succeeded in obtaining from two different localities, one in southern and one in central Peru, wild cavies supposed to be closely related to the domesticated guinea-pig. These will be used in breeding experiments at the Bussey Institution. The event is of interest to zoologists as being probably the first introduction of living individuals of the ancestral guinea-pig into North America or Europe. This fact is the more surprising when it is remembered how extensive and important is the use of the guinea-pig in biological investigation and the public health service. Not only is the wild guinea-pig unrepresented in any zoological garden, but even our greatest museums possess scarcely a specimen of it. The transportation of the animals for several thousand miles through a variety of climatic conditions involved some difficulties, which, however, were all successfully met. Small round market-baskets lined with wire netting served as cages, and cucumbers and watermelons for food during transportation through the tropics. Some domesticated guinea-pigs were also obtained from Peruvian natives for comparison with the ordinary European sorts, which probably reached Europe from South America centuries ago.

A COMPREHENSIVE project for research on the Cactaceae has been organized by the department of botanical research of the Carnegie Institution of Washington. Dr. J. N. Rose, of the U. S. National Museum, who has explored much of the region inhabited by these plants in Mexico and the United States and published extensively on the family, has been appointed research associate. He has been granted a furlough from the museum, which also furnishes working quarters and facilities for handling the living collections. Dr. N. L. Britton, who began organizing a collection of cacti in the New York Botanical Garden in 1900, and has since made extensive studies of the group, has also been appointed research associate, without salary. By the action of the scientific directors of the garden he will be given some respite from other duties to enable him to participate in this work. The garden also contributes its extensive collections, and some of its explorational effort to the project. Dr. D. S. Johnson, of Johns Hopkins University, will spend several in 1911 on the morphology and physiology of the fruits of the group, and Professor J. G. Brown, of the University of Arizona, will continue his studies on the general morphology of *Opuntia* and *Carnegiea* begun while acting as assistant at the Desert Laboratory. Other contributions will be made by the members of the staff and cooperators of the Desert Laboratory.

THE fifth annual meeting of the Illinois Academy of Science will be held at Bloomington, Illinois, Friday and Saturday, February 23 and 24, under the auspices of the McLean County Academy of Science. The sessions will begin at 2:00 P.M. on Friday and will continue through Saturday afternoon. A symposium on Conservation will be given at the Saturday morning session, the speakers and their subjects being as follows:

"Conservation of Our Coal and Oil," F. W. DeWolf, director, Illinois State Geological Survey.

"Water Pollution," Edwin O. Jordan, professor of bacteriology, University of Chicago.

"Conservation Ideals in the Improvement of Plants and Animals," Herbert J. Webber, professor of plant breeding, Cornell University College of Agriculture.

"Conservation of Our Forests," Henry C. Cowles, associate professor of ecology, University of Chicago.

"Conservation of Our Fauna," S. A. Forbes, director, Illinois State Laboratory of Natural History.

"Conservation of the Human Race," J. N. Hurty, secretary, Indiana State Board of Health.

A banquet will be given at the Illinois Hotel on Friday evening, after which the president, Professor W. A. Noyes, will address the academy, the subject being "The Electron

Theory." Many papers of scientific and educational interest will be presented during the sessions.

A COURSE of six lectures under the auspices of the Chicago Nature Study Club is being given at the Academy of Science, Lincoln Park, on Saturday afternoons at 1:30 as follows:

February 10—"Schoolroom Aquaria," Frank C. Baker, curator, Academy of Science.

February 17—"Window Gardening," Aaron H. Cole, Chicago Teacher's College.

February 24—"Beautifying the Schoolyard," Jens Jensen, landscape architect.

March 2—"Trees for the Schoolyard, Street and House, How to Select and Care for them," J. H. Prost, city forester.

March 9—"The Enemies and Diseases of Trees," J. H. Prost, city forester.

March 16—"Birds as Guardians of Trees and other Plants," R. M. Strong, University of Chicago.

WE learn from *Nature* that it is proposed to establish in Dartmouth a permanent memorial to Thomas Newcomen, known for his work in connection with the steam engine, who was born in that town in 1663. A meeting of those interested in the matter has been held in the Dartmouth Guildhall. The mayor of Dartmouth, Mr. Charles Peek, and Mr. T. F. Caston, the honorary secretary to the Newcomen Memorial Committee, will welcome suggestions as to the best manner of perpetuating the memory of the inventor and his invention, and be glad to receive contributions.

THE late Dr. A. S. Packard, of Brown University, planned a series of illustrated volumes on the bombycid moths of North America, to be published by the National Academy. Two volumes were issued during his lifetime. Materials for a third volume, on the large silk-producing moths, were left and these have been placed in the hands of Professor Cockerell, of the University of Colorado, who is editing them for publication.

DR. FRANCISCO P. MORENO, member of the chamber of deputies, Argentina, has introduced a motion in the congress of Argentina for the acquisition by the government, for the Museo Nacional at Buenos Aires, of the great private paleontological collection of Florentino Ameghino.

MR. JOHN D. ROCKEFELLER has given $11,000 toward the purchase of the house in which Pasteur was born in the village of Dôle.

PROFESSOR HENRY WILLIAMSON HAYNES, known for his investigations in archeology, died at his home in Boston on February 15, aged eighty years.

DR. HENRY TAYLOR BOVEY, F.R.S., from 1887 to 1909 professor of civil engineering and applied mechanics in McGill University, first rector of the reorganized imperial College of Science and Technology in London, died on February 2, aged fifty-eight years.

SIR HENRY TRENTHAM BUTLIN, Bart., a leading English surgeon and pathologist, died on January 24, aged sixty-six years.

SIR JOHN CHARLES DALRYMPLE HAY, Bart., F.R.S., admiral (retired) of the British navy and the author of books on naval topics, died on January 28, at the age of ninety years.

M. T. DURAND, member of the Royal Academy of Belgium, director of the State Botanic Garden and general secretary of the Royal Botanic Society of Belgium, died on January 12.

THE death is announced of Dr. L. Pič, the noted Bohemian archeologist, in charge of the unsurpassed archeological collection of the Museum Regni Bohemiae, Prague.

DR. OTTO LIEBMANN, formerly professor of philosophy in the University of Jena, has died at the age of seventy-one years.

THERE will be a New York State civil service examination on February 24, the positions opened including that of first assistant veterinarian in the Department of Agriculture at a salary of $1,800 to $2,400, and bacteriologist in the Health Officers' Department, Quarantine, New York, at a salary of $1,500. The latter position is for women.

THE most notable map publication of the year is the large geologic map of North America just issued by the United States Geological Survey. It represents an exceptional

type of engraving and lithographic color work and is printed in four sheets which fitted together and mounted make a map 6 feet 5 inches high by 5 feet wide, the largest piece of work ever issued by the survey. The scale is 1 to 5,000,000, or 80 miles to the inch, and the plan of projection is in harmony with the universal world map on a scale of 1 to 1,000,000, in that it shows the units of publication of the world map, each of which embraces four degrees of latitude and six degrees of longitude. The color scheme of the map is a striking one. In all there are 42 color distinctions, varying from a brilliant red to pale tints approaching white. These were produced by 14 separate printings from lithographic stones, requiring in many places two or three combinations of color to produce the desired effects. If the weight of paper and heavy stones lifted back and forth in the printing of this job were to be computed it would run into the hundreds of tons. The accuracy of the "register," or fitting together of the color blocks in small areas throughout the map, is remarkable. The work was done in the survey's own engraving and printing plant, and it is believed that there are few if any other establishments in the United States capable of turning out such a production. The 42 color distinctions represent as many divisions of rock strata. Thus the rocks of seven divisions of the Paleozoic era are each represented by a color, besides three separate colors for undifferentiated rocks, and there are other colors for the division of the Mesozoic, the Tertiary and the Quaternary. The coloring of the map is both effective and pleasing. The scheme is systematic in that the colors range in prismatic order from yellow in the upper portion of the geologic column through greens, blues and purples to pinks and browns at the base. The colors for the igneous rocks, both plutonic and volcanic, are mostly bright red. Viewed as a wall map, the map of North America shows only the larger geologic units, as the smaller divisions are represented by different shades and tints of the same or closely allied colors which are indistinguishable at a moderate distance.

The *Journal* of the American Medical Association quotes from the *Journal Officiel* data of the vital statistics in France for the first semester of 1911. There were almost 14,000 fewer births than during the corresponding semester of 1910. Last year the births, which were few enough already, amounted to 399,669. This year there were not more than 385,999. While births diminished, deaths increased. They increased from 378,480 during the first semester of 1910, to 404,278 during the first semester of 1911, an increase of 25,798. During the six first months of the current year the deaths exceeded the births by 18,279. The number of marriages has decreased in a slightly less proportion. There were about 156,761 last year. There are not more than 153,931 this year. Divorces, which last year amounted to about 6,303, in 1911 have increased to 6,374.

The fourth report of the royal commission on university education in London deals with the housing of London University. According to the London *Times* the commissioners state that it had become clear, as the inquiry proceeded, that the inception of any scheme which they might be able to recommend and which parliament might sanction would be seriously delayed unless some steps had previously been taken to provide for the university, as reconstituted, a site and buildings more convenient and adequate than those it now occupied. They think that whatever its future constitution might be, it was a matter of national importance that the University of London should be recognized and adopted as a great public institution; and that it was fitting and right that such an institution should have for its headquarters permanent buildings appropriate in design to its dignity and importance, adequate in extent and specially constructed for the purpose, situated conveniently for the work it had to do, bearing its name, and under its own control. The University of London, it is stated, must depend, like other universities, to a large extent, for the liberal support necessary for its full development upon the endowment of private benefactors. The commissioners thought such benefactors

were to be found; and the inquiry had impressed them so forcibly with the almost unlimited possibilities of the university in the future, that they could not easily conceive a more splendid opportunity than its endowment and the provision of a noble and suitable building for its home afforded for the liberality of the citizen.

ATTENTION is called in the London *Times* to the fact that every year the London Zoological Gardens are visited by large numbers of school children, accompanied by their teachers. The price of admission for these is one penny, and the time spent on the visit is counted as school attendance. The council of the society desired to make these visits more useful, and last year arranged with the education committee of the London County Council for a series of demonstration lectures to school teachers. The Zoological Society arranged the courses, provided the lecture-room and lantern and allowed the teachers free admission to the gardens, while the education authority made a grant towards the expenses. The course, which was repeated three times last session to three separate sets of 150 school teachers, consisted of three lectures illustrated by lantern slides and a demonstration in the gardens, for the latter the teachers being divided into parties of 25. This session it was considered advisable to increase the number of demonstrations in the gardens, and the education committee has increased their grant to make this possible. The syllabus has been made very simple and is devised to cover only such subjects as may be made interesting to school children. In the case of mammals the main types, such as carnivores and herbivores, are considered in relation to their food and modes of obtaining it, their weapons of offence and defence and their chief adaptations to their environment. Birds are similarly treated, but the nesting habits and the care of the young are discussed more fully. The coloration of animals in relation to deserts, snow and so forth are dealt with, and salient examples of mimicry and warning patterns and colors are pointed out. In the demonstration tours in the gardens examples of the questions discussed in the lectures are pointed out. The first lecture for the season was attended by nearly 150 teachers, while four parties of 25 teachers were taken for a demonstration tour in the gardens by the lecturer, Mr. J. L. Bonhote, and his assistant, Mr. J. T. Cunningham. To suit the convenience of teachers, all the lectures and demonstrations are given on Saturday mornings, and the three courses now arranged for will last well on into the early summer of next year.

THE first All-Slav Congress and Exposition of Social Medicine and Hygiene will be held in St. Petersburg during the week commencing May 28, 1912. There will be five sections, the first of which (president, V. O. Gubert), will deal with medicine and hygiene of the masses; the second (president, J. F. Zemackij), with gymnastics and exercises tending towards the better development of the body; the third (president, M. M. Kovalevskij), with social ethics; the fourth (president, A. V. Vasiljev), with the development and health of the child, and the fifth (president, D. O. Ott), with the woman. More in detail, Section 1 will deal with regulation of the medical aid; hygiene of houses and cities; housing problems; nourishment, with price of food; social and hygienic protection of workingmen; combat of prevalent diseases; protection of the mental health of the population; medical education and activities, and cure establishments, springs, etc., with balneotherapy. Section 2 embraces physical exercises; the Sokols (the great Slav gymnastic organization); athletic contests and sports; touristic, and bathing, with swimming. Section 3 deals with abuse of alcoholic beverages; dissipation and specific diseases; suicide, and criminality. Section 4 extends to development of the child; health in infancy; infant mortality; training of the child before school age; school hygiene, and mental development of the child. Section 5, finally, embraces everything relating to the functions and health of the woman.

THE *American Museum Journal* states that in revising the installation of the New Guinea material in the South Sea hall, Dr. Lowie is making extensive use of the sketches secured

by the museum with the Finsch collection. Dr. Otto Finsch, the celebrated naturalist and traveler, provided with the collection a very full series of illustrations accurately picturing many phases of native life. These are highly desirable, as many aspects of aboriginal culture, such as house and boat types can not always be readily transported or even secured in model specimens, although often they form the most characteristic elements of the culture of a tribe. This applies even more emphatically to social and ceremonial life, which can be studied very inadequately, if at all, from museum specimens. It also applies in large measure to objects of personal adornment and clothing. For instance, it would not be at all obvious to the average visitor how the aborigines wore a profusely decorated heart-shaped object conspicuously exhibited in one of the New Guinea cases. A glance at the sketch now beside the specimen shows it to be a warrior's breast ornament. Similar results have been accomplished with other articles of dress which otherwise could not readily be understood except with the aid of long explanatory labels.

The London *Times* states that in the old parish church of St. Mary, Teddington, a tablet has recently been dedicated to the memory of the Rev. Stephen Hales, D.D., a former vicar of the parish and one of the most distinguished men of science of the eighteenth century. A number of eminent living *savants* have for a long time been endeavoring to discover his burial place, in order to preserve his memory, and at length the stone recording his death was found in the floor of the porch of the church with nearly the whole of the lettering obliterated. The new tablet has been placed on the wall of the west porch beneath the tower of the old church, and bears the following inscription:

Beneath is the grave of Stephen Hales. The epitaph, now partly obliterated, but recovered from a record of 1795, is here inscribed by the piety of certain botanists, A.D. 1911. "Here is interred the body of Stephen Hales, D.D., Clerk of the Closet to the Princess of Wales, who was minister of this parish 51 years. He died 14th January, 1761, in the 84th year of his age."

Mr. Francis Darwin has written for the current number of the *Parish Magazine* an interesting account of Dr. Hales, in the course of which he says: "Stephen Hales has been called the 'father of physiology,' and he deserves this title in regard both to animals and plants. His experiments on the blood pressure of animals are second only to Harvey's work on the circulation. In the domain of plant physiology he is equally great. In all his researches he combined a belief in the design of the Creator with a passionate desire to understand the mechanism of living things. Thus he treated the manifestations of life as things to be weighed, measured and analyzed in the laboratory. It is this point of view that gives his work so modern a character and entitles him to be considered one of the founders of a rational science of biology. Although he loved science for its own sake, it is equally clear that he was dominated by a permanent desire to use his knowledge for the benefit of his fellow-creatures. Water supply, ventilation, the distillation of potable water at sea, the preservation of food on long voyages, the treatment of at least one disease—the stone—and especially the harm arising from intemperance in the use of alcohol, all received attention. It is impossible to read his works without mingling personal affection with the respect inspired by his intellect."

UNIVERSITY AND EDUCATIONAL NEWS

After long preparation, ground has been broken for the first Reed College buildings on the campus of eighty acres. The college will open next September in the permanent buildings, and on the endowment foundation of about $3,000,000 provided by Mr. and Mrs. Simeon G. Reed, of Portland. Three buildings, in addition to residences for the faculty, will be ready—the arts building, the dormitory and the gymnasium. All the buildings will be in the collegiate-gothic style of architecture. The material will be Indiana limestone and mission brick. The arts building and dormitory will be of steel and concrete structure, fireproof throughout. The buildings will run against the wooded ravine and lake, which

are picturesque features of the campus. The arts building is 257 feet long, with wings 85 feet long. It has four stories. The estimated cost of the building and furnishings is $225,000. The dormitory, which is virtually five separate dormitories, contains a large clubroom for men students, a dining-hall and rooms and baths for 125 students. The cost of this building, exclusive of furnishings, is $140,000.

THE plan of George M. Pullman for the establishment of a manual training school at Pullman, Ill., is assuming definite form. Professor L. G. Weld, formerly professor of mathematics and dean of the University of Iowa, has been despatched on a tour of America and Europe to collect data to guide the board of trustees in the construction of the buildings and the arrangement of the curriculum. Building operations, it is expected, will be commenced next year. A site of forty acres has been purchased at a cost of $100,000. A fund of $1,000,000 was bequeathed by Mr. Pullman at his death on October 18, 1897, for founding the institution. This fund was invested in securities which have increased in value until now there is about $2,500,000 at the disposal of the directors for the school.

THE University of California announces the establishment by Mr. F. M. Smith, of Oakland, California, of a research fellowship for investigation of certain problems incident to the growth of cities in the San Francisco Bay region. Attention is to be directed especially to questions relating to the development of parks, playgrounds and other community interests demanding particular consideration of space available for growth. The stipend of the fellowship is $1,000 per annum, and an additional sum of $500 annually is provided for expenses of the investigation. The work of the fellow will be conducted under the supervision of a special committee named for this purpose, and the results worthy of record are to be prepared for publication.

$12,500 was recently turned over to the authorities of the Colorado School of Mines for the equipment of the new ore testing plant. The building for the plant was built a year ago and $50,000 was allowed by the legislature for the necessary machinery and one fourth of this is what is now available. Many donations of machinery have been made by the various manufacturers and it will now be possible to completely equip, ready for operation, the concentration section of the plant.

DR. J. B. HURRY has established a research studentship of physiology at Cambridge to be named in honor of Michael Foster.

WE learn from the *Bulletin* of the American Mathematical Society that Dr. G. Schirmer, a Chicago physician, has established at the University of Erlangen, a prize fund, to be known as the Helene Ottilie Schirmer foundation, in honor of his late wife. The income, $150, is to be given to the author of the most meritorious thesis prepared at the university during a period of two years preceding each award; the subjects are to be in mathematics or physics in odd years, and in medicine in even years. The first award has recently been made to Dr. R. Baldus for his dissertation on certain line congruences.

Two new departments are to be established at Swarthmore College next year, one in political science, and the other in psychology and education. Dr. Robert C. Brooks, at present professor of political science at the University of Cincinnati, is to head the political science department, and Dr. Bird T. Baldwin, now professor of education at the University of Texas, will have charge of the work in psychology and education.

DR. C. N. JENSEN, fellow in plant pathology, Cornell University, has been appointed professor of botany and plant pathology in Utah Agricultural College and Experiment Station and entered on his duties on February 1.

DR. ELEANOR H. ROWLAND, professor of philosophy at Mt. Holyoke College, has resigned to become dean of women and professor of philosophy at Reed College, Portland, Ore., but does not enter upon her new duties until next September. She will spend the next semester in Crete, engaged upon research work. Dr. Kate Gordon takes Dr. Rowland's place during the second semester.

Dr. Samuel P. Hayes, professor of psychology, will be in England until next fall.

Mr. C. Shearer, of Clare College, Cambridge, has been nominated to a newly established lectureship in experimental morphology at Cambridge.

DISCUSSION AND CORRESPONDENCE

THE WORD GENOTYPE

Professor Jennings (Science, December 15, p. 847) refers to the fact that the word genotype has two meanings, but does not make it quite clear that both are current at the present time. The use of the word, with a definition, by Schuchert antedates that of Johannsen, as has been several times pointed out. Taxonomists can hardly be expected to abandon their prior and useful term, so it becomes a question whether it is convenient to continue the Johannsenian usage, trusting to the context to indicate in every case what is intended.

Some months ago, in conversation, my colleague, Dr. George Norlin, suggested "amictotype" as a possible substitute for genotype in the sense of Jennings.

T. D. A. Cockerell

University of Colorado

GENOTYPE AND "GENOTYPE"

"In calling attention to the frequent misuse of the word 'genotype'" (quotation from George H. Shull in Science, February 2, 1912, p. 182), the students of heredity will please take notice that this term has been in biology since 1897 and that Shull, Johannsen and others persistently misuse the term. The original definition is as follows:

"*Genotype* (*genos* = race, and *typos* = type).—Genotype applies to any *typical material of the type species of a genus.* The material, however, should be, if possible, from the original locality of the species, or a genotype should also be a topotype or a metatype. Therefore there may be as many genotypes of *Lingula* as there are museums having characteristic specimens of *Lingula anatina.*"[1]

Charles Schuchert

[1] Science, April 23, 1897, p. 639.

SCIENTIFIC BOOKS

Lectures on Fundamental Concepts of Algebra and Geometry. By John Wesley Young, Professor of Mathematics in the University of Kansas. Prepared for publication with the cooperation of William Wells Denton, Assistant in Mathematics in the University of Illinois. With a Note on the Growth of Algebraic Symbolism by Ulysses Grant Mitchell, Assistant Professor of Mathematics in the University of Kansas. New York, The Macmillan Company. 1911. Pp. vi + 247.

Descriptive Geometry: A Treatise from a Mathematical Standpoint. By Victor T. Wilson, M.E., Professor of Drawing and Design in the Michigan Agricultural College. New York, John Wiley & Sons. 1909. Pp. viii + 237.

Elements of Descriptive Geometry with Applications to Spherical and Isometric Projections, Shades and Shadows, and Perspective. By Albert E. Church, LL.D., late Professor of Mathematics in the United States Military Academy, and George M. Bartlett, M.A., Instructor in Descriptive Geometry and Mechanism, University of Michigan. New York, American Book Company. 1911. Pp. 286.

Professor Young's "Lectures" presuppose in the reader intellectual acumen and a certain logical bent but little mathematical knowledge beyond the elements of algebra and geometry. Dealing with such topics as Euclid's Elements, A Non-Euclidean World, Consistency, Independence and Categoricalness of a Set of Assumptions, with the notions of class, correspondence and group, the assumptions of Hilbert and Pieri, dimensionality and hyperspace, variable, function and limit, and dealing with them in a way that is at once philosophic, romantic, scientific and well-nigh literary, the lectures ought to appeal to a wide and diversified class of readers, philosophers, logicians, both expert and inexpert mathematicians, and thinkers in general. The book is far more than its title indicates, for the concepts treated are presented as being fundamental to mathematics in general, to

mathematics regarded as "the universum of exact thought," rather than to algebra and geometry conceived as special branches thereof. Basic concepts and central concepts, though the two categories may intersect, are in general not the same, else the book would doubtless have admitted to a prominent place the notion of invariance, a notion that, besides being of central importance in mathematics, serves to ally the interests of this science with those of science in general, and with those of philosophy, theology, religion and art. It is the chief unifier of the great forms of human interests and endeavor. Professor Young has admirably shown that any science must contain two sorts of ideas, the assumed and the defined; besides these it uses ideas that it does not contain (as subject matter); the like is true of propositions; somebody ought, in respect of some science, to assail the problem of indicating those ideas that are used by the science without being a part of its content. In the chapter dealing with "the logical significance of definitions" Professor Young might well have said, what he doubtless knows, that, for example, the notion of definition is no part of the subject matter of logic or mathematics, though for the sake of convenience the notion is continually there in use. The conception of mathematics presented in italics on page 221 leaves the science without any unity except such as belongs to a mere collection, which can never satisfy. The defect is partly cured on page 225. In a democracy it is a duty of scholars to render scientific concepts intelligible to the public intelligence, and Professor Young's book is a valuable contribution to such high service.

The descriptive geometry treated by Professor Wilson and Professor Bartlett is not to be confounded with that great variety of geometry, called descriptive by Russell and others, which was founded by Pasch in his "Vorlesungen über neuere Geometrie" (1882) and a few years later cast in symbolic form by Peano, but it is that branch of geometry which has for its object the representation of 3-dimensional figures by means of their projections upon two or more planes, a method invented by Gaspard Monge (a peddler's son) in response to military exigencies in France and set forth by him in 1800 in his "Géométrie descriptive." Professor Wilson's aim, "to present a sound theoretical treatment" and not to win the student by means of mere appeal to "short cuts" and his "practical" interest, is laudable. As to the extent to which the end has been attained, some mathematicians may be disappointed in not finding here a system of postulates. On the same page (2) we are told that parallel lines are said to have two points in common at infinity, that parallel planes meet each other in a common line at infinity, and that descriptive geometry and perspective are a part of projective geometry. The traditional use of "line" for curve is adopted. Two consecutive points are regarded as points "infinitely close" together but not coincident (p. 81) and as coincident points (p. 93). The statement that "the secant approaches tangency and become such when the two points [of secancy] become coincident" will serve (even after typographical correction) to exemplify a not infrequent occurrence in the book of unprecise statement. One can not but feel that so good a book ought to be better. Typographically and mechanically it is pleasing; there is appended a goodly list of exercises; and the point of view is somewhat more general than is common in American text-books in this subject.

When will some breath of modern mathematics get into our text-books of descriptive geometry? Church's "Elements," published in 1864, has reigned, partly because of its merits, for nearly five decades. To meet the new demands in respect of matter and of presentation, Professor Bartlett has not deemed it necessary to depart essentially from the venerable text of Church. Consequently this interesting and instructive new volume has the scientific odor of a geometric past, despite the excellence of the drawings and pictorial representations of certain more

difficult problems. On page 63 we are invited to think of a moving point as going from one position to the "next." Two points thus next to each other *form* an infinitely small straight line. The two points are consecutive, without distance between them, and "may practically be considered as one point." No talk about limit: a curve is, for thought, composed of infinitely short straight lines. The term locus does not appear except incidentally as on page 84. But "if a point moves so as continually [not continuously] to change its direction from point to point, the line generated is a curved line, or curve." According to the highest mathematical standards, descriptive geometry has not attained, in America, to the rank of a science. It is a tool. Judged as a work designed to teach the use of an important tool, Professor Bartlett's book will render good service. But such books ought to get up-to-date in respect to logic, geometric spirit, conception and nomenclature.

COLUMBIA UNIVERSITY C. J. KEYSER

Les Poissons Wealdiens de Bernissart. By RAMSEY H. TRAQUAIR, M.D., LL.D., F.R.S. Extrait des Mémoires du Musée Royal d'Histoire Naturelle de Belgique, T. VI. Bruxelles. 1911. 4to. Pp. iv + 65; 12 pls. and 21 text figures.

In this memoir Dr. Traquair—the dean of paleichthyologists—discusses the fishes of the Wealden, or basal Cretaceous, of Belgium. This formation, though known chiefly for fine skeletons of the dinosaur *Iguanodon,* contains also a highly interesting fish-fauna. This is remarkable for the fact that its species, though relatively few (sixteen), represent both the more archaic members of the group of ganoids as well as the quite modern teleosts. In discussing this fauna, therefore, Dr. Traquair has opportunity of reviewing at once such forms as *Coccolepis,* the last survivor of the Palæoniscidæ, as well as *Leptolepis,* the earliest of the clupeoids.

The memoir is of necessity devoted mainly to systematic details; none the less broader questions, such as those of morphology, relationship and geological distribution, are not overlooked. And all these themes are treated with the author's characteristic painstaking regard to fact. In short, the memoir is an example of what a systematic review of a fossil fauna should be.

An interesting and very useful feature is the carefully drawn restorations, of which there are thirteen. Especially noteworthy are those of *Coccolepis, Callopterus, Amiopsis, Mesodon* (with new interpretations of the cranial elements) and *Aethalion.* These figures are sure to follow the many others from the same hand, and become part of the stock in trade of all writers on ichthyology.

The fauna of Bernissart, as a whole, is regarded as fresh water. The chief evidence for this view is the entire absence of sharks from this formation, although the group is abundantly represented in other European rocks of equivalent age.

To the friends of Dr. Traquair—and they are many, both in Europe and America—the publication of this memoir has an especial interest. For it shows the doctor, who is past his seventieth anniversary, still working away, with his old-time vigor and enthusiasm, in the field which he has done so much to advance.

Ave Magister! Many be the years
That lie before thee, thronged with busy hours![1]

L. HUSSAKOF

AMERICAN MUSEUM OF NATURAL HISTORY

THE HARRIS TIDAL MACHINE

THE Coast and Geodetic Survey has recently put in operation, after a thorough test, a new tide-predicting machine, which performs simultaneously all the operations of the British or Thomson machine and of the first American machine invented by Professor Ferrel. As in the Thomson machine, the tidal curve is drawn from which the height of the tide at any time may be scaled off, but, in addition to this, the times of high and low water are marked upon its axis, and both the time and height of the tide, as well as the height of the water's surface at any given

[1] Dr. S. Weir Mitchell, "The Comfort of the Hills and Other Poems," p. 95. New York, 1910.

time, are shown upon graduated circular dials on the face of the machine. The machine was invented by Dr. R. A. Harris, who seventeen years ago published a brief but comprehensive description and submitted a general plan to the Coast Survey Office. (See report of superintendent for 1894.) The details of the machine-design were worked out by Mr. E. G. Fischer, under whose direction the machine was set up in the instrument division of the survey.

Mechanical aids of this kind are used in connection with the tides, because good predictions require the combination of a considerable number of sine or cosine terms whose arguments vary uniformly with the time. The new machine contains 32 short-period components (*i. e.*, daily, semi-daily, quarter-daily, etc.) and 7 having long periods (*i. e.*, fortnightly, monthly, semi-annual and annual.

In combining these numerous terms two summations are carried on continuously by means of two chains each fixed at one end and free to move at the other. Each chain is laid alternately over and under a series of pulleys whose upward and downward movements cause the free end of the chain to travel back and forth across a fixed initial point. The motion of the free end of one of the chains is proportional to the rise and fall of the tide to be represented or predicted; that of the free end of the other chain (or rather of a marked link a certain distance from this end) is such that when this link passes across a fixed point the height represented by the first chain is at its maximum or minimum value. These statements describe very briefly the general plan upon which the times and heights of the tides are mechanically determined. As already stated the times and heights are shown upon the face of the machine while a curve is drawn which makes a permanent record of all stages of the tide.

The machine is driven by hand and the gears are such that the periods of motions which depend upon them shall represent the known periods of the various sine and cosine terms into which tidal records or observations can be resolved.

In the new machine the error resulting from the representation of the incommensurable astronomical ratios by the gears amounts to less than one degree for a period representing a year in prediction. For the larger terms the error is much less, so that after predicting a year's tides and reading hourly heights for December 30 and 31, the predicted values agreed so well with the values computed directly from astronomical data, as to make the errors negligible.

It may be stated that, although tide-predicting is the most useful purpose to which the machine is put, its broadest application is in the solution of equations of the form
$$y = H_0 + A \cos(at + \alpha) + B \cos(bt + \beta) + \cdots,$$
where $A, B, C, \ldots$ denote the amplitudes and $a, b, c, \ldots$ their speeds per unit of time t, of which it draws the graph and indicates the positions and magnitudes of the roots.

SAMUEL TIERNEY, JR.

SPECIAL ARTICLES

XERALEXIS

WHOEVER brings forward a new word must show what the students in journalism would call a "crying need" for it, or take the consequences. The undersigned is not altogether certain as to how crying the need may appear to others, but it seems to him that a single euphonious, appropriate word should be sought to replace the clumsy and rather ill-sounding compound, "drought-resistance." The writer proposes the coining of the word *xeralexis*, from the Greek ξηρότης, drouth, and ἀλέξησις, a keeping off or resistance.

We have, of course, the words, "xerophytic" and "xerophytism," which do not, however, involve the idea of resistance to drouth in their composition, and do not convey that meaning in usage, although it stands to reason that a "drouth-resistant" plant will have "xerophytic" characteristics of some kind.

There is ample justification for the new word on etymological grounds. The Greeks had many compounds in which the above roots were employed. The root of the adjective *xēros*, "dry" and *xērótēs*, "drouth," is found

in *xērophthalmía*, a dryness of the eyes; *xērobiotikós*, living on dry land; *xērophagía*, the eating of dry food, etc.

The root of the word *aléxein*, "to ward or keep off, to turn away or aside," and *aléxēsis*, "resistance or warding off," is found in such combinations as *alexanemía*, "shelter from the wind," or where Sophocles in the *Œdipus*, uses the adjective *alexímoros*, "warding off fate or death" (*μόρος*). Hipparchus uses *alexiphármakos*, in the sense of "warding off poison," or "acting as an antidote."

So the examples might be multiplied. It is strange that the Greeks did not themselves coin a word for "drouth-resistance," for they had and have an abundance of drouth to resist in Hellas, as any one who has ever been there in the summer-time can abundantly testify. It would be interesting to investigate modern Greek terminology on this point.

A euphonious compound of the two above roots can only be made by putting the root for drouth first; although the Greek tendency in the formation of compounds involving *alexein*, in the sense of "warding off," "defending," seems to put the latter first, as in *Aléxandros* (Alexander)—defender of men (anēr, man)—in the examples given above, and many others. To follow this practise and coin such a word as *alexixerótēsis* might be possible for a Greek, but not for us.

Let us accordingly turn the roots around. We then find that we have available for the first member of the compound, two possible nouns, viz., *aléxēsis* (ἀλέξησις)—"a keeping off" or "resistance," and *aléxis* (ἀλέξις) "help"—both from the same root as the verb *alexéo* or *aléxō* (ἀλεξέω, ἀλέξω), infinitive *aléxein* (ἀλέξειν)—a verb which has both the primary signification of to "ward off" or "resist" and the derived one of "to help." Here we encounter a difficulty. If we follow a natural analogy and say *xeraléxis*, following "prophylaxis" from the Greek *phulaxis* (φύλαξις), a "watching" or "guarding," then we seem to imply a derivation from the word *aléxis*, "help," rather than from *aléxēsis*, "warding off." But on the other hand, "*xeraléxēsis*" is slightly longer than "drouth-resistance." There remains, of course, the possibility of following another valid Greek analogy, and saying *xeraléxia*.

On the whole, however, *xeraléxis* is preferable on the score of brevity and ease of pronunciation. Perhaps we are justified in calling it a "contract form" of "*xeraléxesis*," if that will satisfy the philologists.

We then have for "drouth-resistance," *xeralexis* and for "drouth-resistant," *xeralectic*. In the writer's estimation these words might well replace in botanical language generally, not only our English compound, but the awkward French *résistance à la sécheresse*, or the German *Austrocknungs-resistenz*. At all events the new word is logical—as logical as "ecological" in fact.

H. F. Roberts

CRYPTOBRANCHUS ALLEGHANIENSIS, LARUS ATRICILLA AND LARUS MARINUS IN NORTH DAKOTA

In a recent article,[1] Pope has recorded the hellbender (*Cryptobranchus alleghaniensis*) and the laughing gull (*Larus atricilla*) as abundant, and the black-backed gull (*Larus marinus*) as occasional at Devils Lake, North Dakota. These records, if verified, would be of much interest, extending the range of the hellbender to the northwest of that hitherto recognized and bringing the laughing and black-backed gulls from the Atlantic coast far into the interior. In three summers spent in this region, however, I have been unable to verify Pope's records and seriously question their accuracy, both for this reason and because of their inherent improbability.

Franklin's gull (*Larus franklini*) a bird which might readily be mistaken by an inexperienced observer for the laughing gull (*L. atricilla*) is a common breeder in this locality, after the breeding season gathering in large flocks upon the lake. Pope has probably mistaken the ring-billed gull (*Larus delawarensis*) for the black-backed (*L. marinus*). I

[1] Pope, Thomas E. B., "Devils Lake, North Dakota. A Study of Physical and Biological Conditions with a View to the Acclimatization of Fish," Bureau of Fisheries Document, No. 634.

have not taken specimens of the former and hence can not speak positively of its occurrence. It has been recorded, however, by competent field observers,[2] and since its recognized breeding range includes North Dakota, while that of the latter is the northern Atlantic coast, its occurrence here is far more probable than that of the latter.

The only common salamander in the lake is *Amblystoma tigrinum,* which occurs in considerable numbers. I have seen no specimens of *Cryptobranchus* from the lake, and unless Pope's record is supported by specimens, it must be regarded with grave suspicion.

ROBERT T. YOUNG

UNIVERSITY OF NORTH DAKOTA

THE AMERICAN MICROSCOPICAL SOCIETY

THE meeting of the American Microscopical Society at Washington was purely a business session. The following officers were elected: *President,* Professor F. D. Heald, University of Texas; *First Vice-president,* Professor F. Creighton Wellman, Tulane University Medical School; *Second Vice-president,* Mr. Edward Pennock, Philadelphia, Pa.; *Custodian,* Mr. Magnus Pflaum, Meadville, Pa. Professors A. M. Reese, University of West Virginia; F. C. Waite, Western Reserve Medical School, and W. F. Mercer, of Ohio University, Athens, Ohio, were chosen elective members of the executive committee. Professor T. W. Galloway, Millikin University, and Dr. Brayton H. Ransom, of Washington, were elected to represent the American Microscopical Society in the council of the American Association for the Advancement of Science.

The business of prime importance was the determination of the future use of the Spencer-Tolles Fund for the encouragement of research, which now amounts to about $3,500. The fund has been allowed to accumulate for a number of years without any productive use. It was agreed (1) that proper steps should be taken to safeguard the fund in case of the failure of the society; (2) to use the fund to encourage research within the society; (3) to begin the productive use of the fund at once, so that its memorial character may be realized.

More than one hundred new members and subscribers have attached themselves to the society during the year, and 1912 gives promise of being the most successful and prosperous in the history of the society.

In the absence of the president, Dr. A. E. Hertzler, Professor C. E. Bessey presided over the meeting of the executive committee, and Professor M. J. Elrod over the business session.

T. W. GALLOWAY,
Secretary

THE SOUTHERN SOCIETY FOR PHILOSOPHY AND PSYCHOLOGY

THE seventh annual meeting of the Southern Society for Philosophy and Psychology was held at Washington, D. C., on Wednesday, Thursday and Friday, December 27, 28 and 29, 1911, in conjunction with the American Psychological Association and the American Association for the Advancement of Science. The meetings were held in the George Washington University Medical School, President Shepherd Ivory Franz presiding. The programs for December 27 and 28 were arranged jointly with the American Psychological Association. Following the joint meeting on Thursday afternoon came the president's address on "New Phrenology." On Thursday evening the members of both societies were entertained at a smoker held at the New Fredonia Hotel by Professors Franz and Ruediger.

The following items were passed upon at the business meeting held on Friday morning, December 29:

1. The proposed amendment to Art. II., Sec. 3, of the constitution was adopted.

2. It was resolved that the existing arrangement with the Psychological Review Publishing Company be continued as optional to the members of the Southern Society and be handled as hitherto by the secretary of the society. In the future, however, this option is available only to members residing in the southern territory, but it is no longer restricted to those who are new subscribers. Notice of the above arrangement is to be printed after the constitution on the membership list.

3. The secretary was authorized to drop the names of members after one year of delinquency.

4. The determination of the time and place of the next meeting was left in the hands of the council.

5. The treasurer's report was audited by the council and showed a balance on hand, December 23, 1911, of $65.64.

[2] Messrs. Alf Eastgate, of Tolna, and Elmer Judd, of Cando, N. D.

6. The following officers were elected for the year 1912: *President*, Robert Morris Ogden, University of Tennessee; *vice-president*, H. J. Pearce, Brenau College, Gainesville, Ga.; *secretary-treasurer*, William Carl Ruediger, The George Washington University; *councilors*, Shepherd Ivory Franz, John Brodus Watson (for 3 years) and W. B. Lane (for 1 year).

7. The following persons were elected to membership: Samuel Claman, Howard University; H. E. Cunningham, Lookout Mountain, Tenn.; Gardner C. Basset, Johns Hopkins University; Williston S. Hough, George Washington University; Edmund B. Huey, Johns Hopkins University; Herbert Charles Sanborn, Vanderbilt University.

8. Votes of thanks were extended to Dean W. C. Borden for the use of the George Washington University Medical School and to Professors Franz and Ruediger for the smoker.

THE GEOLOGICAL SOCIETY OF AMERICA

The twenty-fourth annual meeting of the Geological Society of America was held at the new National Museum at Washington, D. C., from Wednesday to Saturday, inclusive, of Christmas week, and was the largest in the history of the organization, there being a registered attendance of 140 fellows and 14 fellows-elect, besides many visitors. Professor William Morris Davis, president for the year, presided, having made a special trip for the purpose to America from Paris, where he is serving as Harvard exchange professor at the Sorbonne. The first session of the society was occupied with matters of business. The secretary reported the election of twenty-nine new fellows, making the present active membership of the society 351.

During the past year, there were lost by death Samuel Calvin, for many years state geologist of Iowa; Samuel F. Emmons, a noted mining engineer who was connected with the United States Geological Survey from its organization and was a member of the National Academy of Sciences; Christopher W. Hall, professor of geology at the University of Minnesota; Edwin E. Howell, of Washington, D. C., and Amos O. Osborn, of Waterville, N. Y. One foreign correspondent, Professor A. Michel-Lévy, a famous French geologist, died. An indication of the activity of the society was the publication during the year of a volume of its *Bulletin*, consisting of 738 pages of text and 31 plates, and including part of the papers read at the last preceding annual meeting, which was held at Pittsburgh a year ago. A large part of the volume was devoted to E. O. Ulrich's contribution, "A Revision of the Paleozoic Systems."

In the course of the meeting the following papers were offered:

New Evidence on the Taconic Question: Arthur Keith.

The reasons were given in this paper for reopening the old controversy and for selecting the north end of the Taconic Mountain as the crucial place. The principal views regarding the rocks of the Taconic Mountains were briefly outlined and the geology of the region summed up. Five subdivisions of the Stockbridge limestone around the north end of the Taconics were described and attention called to the extreme folding and metamorphism of the rocks. The slates of the mountains are sharply outlined from the Stockbridge limestone and the contact follows a rude semicircle around the end of the mountains. The characters of this plane of separation were discussed and the conclusion reached that they can only be due to faulting. The bearing of this conclusion was briefly considered.

Some Features in the Grand Canyon of Colorado River: N. H. Darton.

Several years ago, the author measured sections at a number of points along the Grand Canyon to determine the stratigraphy of the Arizona Plateau. These sections were presented, and there was exhibited a colored preliminary geologic map of the Vishnu, Bright Angel and Shinumo quadrangles similar to one now in the corridor of El Tovar hotel at Grand Canyon.

Covey Hill Revisited: J. W. Spencer.

This remarkable hill terminates the northeastern point of the Adirondack plateau (1,030 feet above tide). It is capped with Potsdam sandstone thinly covered with drift. This hill is separated from the main plateau by a broad depression from which the drift has been swept away. Its removal is commonly attributed to the broad trough being a spill-way for a glacial lake. This question is not raised except that it may have belonged to an epoch before the Iroquois period. The broad trough is incised by a deep gorge—the Gulf. Its character has not been fully described. This heads in a small channel such as is being formed to-day, with the increase in size due to the undermining of the walls of jointed sandstone where the blocks are forced off by frost action. Thus the gorge can not be taken as evidence of a greater drainage

than at the present time. The gorge is post-Glacial for this reason, and does not represent the outflow from a glacial lake. A beach on the northern flank of the hill at 450 feet above tide has been supposed to be marine without the showing of any evidence. Upon revisiting the hill no evidence of the marine character was found.

Dr. Spencer's paper was discussed by J. B. Woodworth and H. L. Fairchild, and reply was made by the author.

Pre-Cambrian Formations in South-central British Columbia: Reginald A. Daly.

A reconnaissance along the Canadian Pacific Railway line has established the following conclusions: (1) Dawson's "Nisconlith series" occurring in the Selkirk Mountains is not Cambrian, but represents the northern continuation of the "Beltian" (Belt terrane) rocks at the International Boundary. (2) Dawson's "Nisconlith series" of the Shuswap Lakes area (west of the Selkirks) is an entirely different pre-Cambrian and pre-Beltian group of sediments, which unconformably underlie the "Nisconlith series" of the Selkirk section. (3) The Adams Lake volcanic series conformably overlies the thick limestones of the "Nisconlith series" in the Shuswap Lakes area and is of pre-Beltian age. (4) The "Shuswap series" of the Shuswap Lakes is not a distinct gneissic group unconformably underlying the "Nisconlith series," but is the facies of the "Nisconlith series" produced where that series was thermally metamorphosed by batholiths. (5) Though these pre-Cambrian rocks are typical crystalline schists, their metamorphism of the regional type was not due to dynamic action; it was "static" metamorphism (Belastungsmetamorphismus of Milch). (6) The pre-Cambrian rocks are much less deformed (upturned) than the overlying Carboniferous or Triassic rocks, illustrating the small depth of the earth-shell which underwent strong folding in post-Cambrian time. (7) The petrography of this pre-Cambrian and pre-Beltian terrane strongly suggests that it furnished the greater part of the clastic material of the Rocky Mountain geosynclinal prism.

Origin of the Sediments and Coloring Matter of the Eastern Oklahoma Red Beds: J. W. Beede.

Recent investigations seem to show that the sediments of the lower red beds of Oklahoma were derived from the Arbuckle-Wichita Permian land mass. The conclusion is based on the amount of material removed and the geographic distribution of sediments bordering the mountains. Coarse limestone conglomerate of great thickness and conglomerates of crystalline rocks—both possibly of subaerial origin—dovetail into red beds. Belts of sandstone have been found extending into the area of finer sediments farther away from the mountains, apparently indicating the location stream debouchures at the margin of the shoal sea. The extreme shallowness of the water is clearly indicated in the structure of the beds. The coloring matter is thought to have been derived from the solution of the 8,000 or 10,000 feet of pre-Carboniferous limestone which formerly covered the Arbuckle-Wichita Mountains and much of the surrounding region. The solution of the limestone furnished optimum conditions for the oxidation of its iron content, as it does at the present time in the limestone regions of the Mississippi Valley, southern Europe, West Indies, etc. Moreover, the solution of the pre-Carboniferous limestones and the conglomerates of the Arbuckle-Wichita region now in progress produces a red residuum practically indistinguishable from red beds sediments. The red granites, red porphyries and other crystalline rocks of the region under discussion contributed their share of material to the red beds. Other factors may have entered largely into the formation of the red beds of western Oklahoma.

The paper was discussed by I. C. White.

Correlation of Rocks in the Isolated Coal Fields around the Southern End of the Rocky Mountains in New Mexico: Willis Thomas Lee.

Several isolated coal fields in New Mexico, near the southern end of the Rocky Mountains, were visited, notably those near Cerrillos east of the Rio Grande and those on the Rio Puerco. Stratigraphic studies were made and fossil leaves and shells collected from the coal-bearing rocks and those stratigraphically near them, with two objects in view: first, of fixing the age of the coal beds, and second, of correlating the formations of the great coal fields on opposite sides of the mountains by means of the data from these small fields intervening between them.

Monument Creek Group and its Relations to the Denver and Arapahoe Formations: G. B. Richardson.

The Monument Creek Group, Hayden's name for several thousand feet of arkosic deposits on the Platte-Arkansas divide in Colorado, is separated into two parts on the basis of a well-marked unconformity. The rocks above the break carry titanotherium bones of Oligocene age, and the rocks below contain leaves of Eocene age. The

lower parts of these lower deposits strike into the Arapahoe and Denver formations of the Denver Basin, and it appears that those formations are equivalent to part of the lower division of the "Monument Creek."

Dark Scale of Hardness: ALFRED C. LANE.

The hardness of a mineral is its resistance to shearing stress. Like other properties of minerals, it may differ in different directions. When two similar surfaces are rubbed together, the softer mineral leaves a powder (streak) on the other. In order to be sure which mineral gives the streak, it is at times convenient to have besides the common Mohs scale of hardness, composed of light minerals, a "dark scale of hardness" of minerals whose color and streak is dark, especially in teaching. For such minerals, the following properties are desirable: quickly recognizable, easily obtainable, hardness uniform. The following minerals have been used by the writer: (1) graphite, with 1 good cleavage, at one extreme in the white scale, at the other extreme in the black; (2) stibnite (Sb_2S_3), with 2 good cleavages, bladed; (3) galenite (PbS_2), with 3 good cleavages; (4) iron (use soft wire nail), magnetic, ductile; (5) niccolite (NiAs), characteristic color, no cleavage; (6) magnetite (Fe_3O_4), magnetic, brittle. The minerals mentioned seem fairly satisfactory. Above six, the author does not know whether spinel or some other mineral would be more desirable, but as there are comparatively few minerals concerned, it is not important.

Demonstration of Relative Refraction: ALFRED C. LANE.

The method of determining relative index of refraction developed by Exner, Becker and Schroeder van der Kolk[1] may be demonstrated to a class as follows: A large beaker of water placed just a little to one side of a window or other source of light will show a bright streak on the farther side, having a higher index than the surrounding medium. A test tube full of air placed in the beaker will show a bright streak of total reflection on the nearer side, the air within having a smaller index than the surrounding medium.

A Stratigraphic Study of the Appalachian and Central States with Reference to the Occurrence of Oil and Gas: GEO. H. ASHLEY.

It has always been supposed by the oil and gas men that the Appalachian region, extending from Pennsylvania to Alabama, was a stratigraphic unit, and it has been a mystery that eastern Kentucky, Tennessee and Alabama should not yield as much oil and gas as Pennsylvania or West Virginia. The mystery largely disappears when a comparative study is made of the stratigraphy of the Appalachians as a whole. The paper compares graphically the stratigraphy of the southern and northern Appalachians and the central states with reference to the occurrence of oil and gas.

The paper was discussed by H. B. Kümmel.

Granularity Limits in Petrographic-microscopic Work: FRED E. WRIGHT.

In this paper the petrographic microscope is treated as a measuring device for the exact determination of the optical properties of crystal plates, especially of minute crystal fragments and of crystallites. The methods now available for the purpose are considered briefly with special reference to their accuracy and applicability to the investigation of fine-grained silicate preparations. Attention is directed in particular to the lower granularity limits at which satisfactory measurements of the different optical properties of a mineral grain can still be made.

The Arkansas Diamond-bearing Peridotite Area: L. C. GLENN.

Evidence will be offered of the circulation of presumably thermal waters about the margin of the original pipe described by Branner. A supposed extension of the peridotite area proves to consist of disintegrated peridotite mixed intimately with well-rounded quartz sand and occasional water-worn chert pebbles and was evidently water-laid. Indications of the age of this material will be given, narrowing down the period within which the extrusion of the peridotite must have occurred.

The paper was discussed by A. H. Purdue.

Resins in Paleozoic Coals: DAVID WHITE.

Resins are present in most coals, except possibly those of the highest grades, the amount depending in general on the degree of concentration (residual) resulting from the decay and reduction of the attending plant structures. Interesting examples of megascopic resins in coals from the Carboniferous of the Mississippi Valley and Montana indicate the presence of resin in the Paleozoic coals in proportions probably as large as in the coals of the Mesozoic and Tertiary.

Onyx Deposits in East Tennessee: C. H. GORDON.

The existence of onyx deposits in east Tennessee has been known for a long time, and attempts have been made at recurrent intervals to utilize the

[1] Report Michigan Geological Survey, Vol. VI., p. 154.

material. Thus far no success has attended these efforts, but with persistent frequency hopes are aroused over some new "find" and glowing announcements are made of the possibilities of this industry. The onyx found is of cave formation and for the most part represents the remnants of vanished caves. The character and extent of the deposits was discussed and the possibilities of their commercial development.

Variation of the Optic Angle of Gypsum with Temperature: EDWARD H. KRAUS.

By using an oil bath to determine the variation of the angle of the optic axes of gypsum at different temperatures it is found that gypsum is optically uniaxial at approximately 90° C. for sodium light. Although Mitscherlich observed in 1826 that this change takes place at about 92°, the values given later by Des Cloizeaux, and more recently by Tutton, both of whom used air baths, are from 15° to 26° too high. Nevertheless, Des Cloizeaux's value of 116° C. for red light is the one commonly quoted. By plotting the values of the apparent angles of the optic axes at various temperatures up to 132.5° C., it is easily seen that the angle changes most rapidly in the vicinity of the uniaxial point, that is, between 80° and 100°, and further, that one axis, as was pointed out by Naumann, changes its position more rapidly than the other.

Notes on the Paragenesis of the Zeolites: J. VOLNEY LEWIS.

Zeolites and other secondary minerals occur in the Newark igneous rocks of New Jersey: (1) in cavernous spaces in the ropy pahoehoe of the extrusive Watchung basalts; (2) in fault fissures and fault-breccia of both the basalts and the great intrusive sill (Palisades, Rocky Hill and Sourland Mountain); (3) less commonly in the ordinary joint cracks of both the extrusive and the intrusive types. The rocks are essentially the same in both chemical and mineral composition, consisting essentially of pyroxene and plagioclase feldspars, with quartz-bearing and olivine-bearing facies. The zeolites and related silicates are essentially combinations of the feldspathic elements and water, with the addition of fluorine in apophyllite and boron in datolite; the accompanying amphibole, biotite, chlorite, epidote, serpentine and talc are derivatives of the pyroxenes. Hypotheses of origin dependent on the action of meteoric waters are inapplicable on account of difficulties of circulation, deoxygenation and sources of fluorine and boron; on the other hand, contact metamorphism by the intrusives has produced in the adjacent shales minerals into which fluorine and boron enter, presumably by emanation from the magma. Hence magmatic waters are regarded as the most probable agent in the formation of the zeolites and accompanying minerals.

The paper was discussed by A. C. Lane and F. R. Van Horn.

Peculiar Iron Ore from the Dunham Mine, Pennsylvania: W. S. BAYLEY.

No abstract received.

Glacial Deposits of the Continental Type in Alaska: R. S. TARR and LAWRENCE MARTIN.

The glaciation of the interior of Alaska forms a striking contrast with the coast, where glacial erosion forms predominate, the deposits being largely under water, except for (1) 1,600 square miles east of Yakutat Bay, (2) 16,000 square miles in the Cook Inlet-Susitna Valley region, and smaller areas. The interior, between the coast ranges and the Endicott-Rocky Mountain system, where the National Geographic Society's party made some studies in 1911, has extensive glacial deposits of the continental type, previously described in part by Russell, Brooks and others and similar to those of the United States. These include at least (*a*) 15,000 square miles in the Copper River basin, (*b*) 27,000 square miles in the Tanana and Kuskokwim valleys, (*c*) 17,000 square miles in the Yukon Flats, (*d*) several thousand square miles on the Upper Yukon region in Canada and smaller areas. The dominant material is outwash and this extends long distances outside the country actually glaciated. In places there is wind-blown loess associated with this. In some localities it is still being deposited, and in the Copper River basin it has been accumulating during the time required for the growth of six or seven generations of trees. There is also some till, but this is largely buried beneath outwash. Lake deposits, eskers, kames and buried vegetation are also found, but thus far no one has found drumlins. In thickness, some of these deposits rival those of the middle west, one instance being known of probably 800 feet of gravel, sand, etc., grading out from the mountains to less than 100 feet fifty miles away. The presence or absence of these drift deposits seems to be chiefly a matter of favorable topography and existing deglaciation, a process much like that formerly in progress in northeastern and central United States.

The paper was discussed by W. M. Davis, C. A. Davis and H. M. Eakin.

Glaciation in Northwestern Alaska: PHILIP S. SMITH.

In northwestern Alaska there are small existing glaciers and evidence of much greater alpine glaciers in the geologic past. The present communication aims to set forth some of the observations made by parties from the U. S. Geological Survey during the field season of 1910 and 1911 in the Kobuk and Noatak regions of northwestern Alaska, which bear on the glacial phenomena.

Pre-Wisconsin Glacial Drift in the Region of Glacier Park, Montana: WM. C. ALDEN.

Along the east front of the Rocky Mountains from Two Medicine Lake northward to the International Boundary, valleys of most of the streams issuing from the mountains are bordered on either side by high, flat-topped ridges, whose crests stand 800 to 1,600 feet above the adjacent valley bottoms with maximum elevations ranging from 5,800 to 6,400 feet above sea level. These high flat-topped ridges taken together have the appearance of being remnants of a continuous high-level plain bordering the base of the bold mountain front and they have been so interpreted by Salisbury, Calhoun, Willis and Finley. Examination of nine of these ridges, those adjacent to Two Medicine, Cut Bank, Boulder, Swift Current and Kennedy creeks, and St. Marys and Belly rivers, and of high benches at corresponding levels on the west side of Belly River, shows the massive ridges to be composed of Cretaceous shales and sandstones with a capping of glacial drift ranging in thickness from 100 to several hundred feet. Fresh scarps resulting from recent slumping afford excellent exposures of the typical glacial till containing abundant striated boulders. In several places much of the till is cemented to a hard tillite conglomerate. In some places, as in the type exposure of Willis's "Kennedy gravels," the material is coarse, sub-angular to rounded cobble-stone gravel composed principally of quartzite, but even here careful search yielded numerous striated pebbles. Striated pebbles and boulders were found on the extensive flat top of Milk River Ridge eight miles from the mountain front. The component material in all cases is derived from the mountains. During the last great epoch of glaciation, the glaciers extended down nearly all the intervening valleys, in some cases nearly filling them. Cut Bank Glacier spilled through sags in the crest of Milk River Ridge, and St. Marys Glacier laid its lateral moraine along the upper slope and lower part of the crest of St. Marys Ridge, but in some places the high level drift rises above that of these valley glaciers and is quite distinct therefrom, though of similar lithological composition. The topographic relations, cementation and considerable amount of modification due to weathering indicate that the high level drift is much older than that in the valleys, and represents a distinct and earlier stage of glaciation separated from the Wisconsin by a long interval during which much erosion was accomplished. Although the relations have not yet been carefully studied, it appears that this older drift includes some at least of the "quartzite gravels" described by the authors cited above, and regarded as pre-Glacial and possibly, but not certainly, some of those described by Dawson and McConnell in southern Alberta and denominated "Albertian Drift."

The paper was discussed by W. W. Atwood and A. P. Coleman.

Some Glacial Deposits East of Cody, Wyoming, and their Relation to the Pleistocene Erosional History of the Rocky Mountain Region: WM. J. SINCLAIR.

Twelve miles east of Cody, Wyoming, in the Eocene badlands in the vicinity of McCulloch Peak, angular blocks of Paleozoic limestone occur at elevations of 6,000 feet above sea, either on the crests of narrow ridges separating deep valleys cut in the badland clays or on terraces several hundred feet above the Shoshone River. No other rocks than limestone have been seen in these high level deposits, but at lower levels abundant pebbles and boulders of andesite may be found, all of which are water worn, while the high level material is highly angular, the only sign of abrasion being the pitted surface produced by the solvent action of rain water. Corals and bryozoa frequently appear in relief on the rain-etched surfaces. Individual fragments vary in size from a few inches or less to blocks $6 \times 8 \times 4$ or 5 feet. The source of the limestone is, undoubtedly, the Paleozoic formations of the mountains to the west of Cody. Glacial ice is the only known agent capable of transporting blocks of the size indicated. If they have been transported by ice, 1,200 feet or more of canyon cutting has intervened since their deposition, for they are stranded on narrow divides and comb ridges at least that high above the Shoshone River. If they are to be correlated with the first glacial advance in the Rocky Mountain region, much of the deep dissection of such intermontane troughs as the Bighorn Basin

must be regarded as an event of Pleistocene time.

The paper was discussed by W. W. Atwood and Wm. M. Davis.

Fossils of Lower Limestone of the Steep Rock Series: C. D. WALCOTT.

The paper described a new genus and two species of sponges found by Dr. A. C. Lawson in the limestone of the Steep Rock Series of Canada.

The paper was discussed by A. P. Coleman.

Evidence of Three Distinct Glacial Epochs in the San Juan Mountains of Colorado: WALLACE W. ATWOOD and KIRTLEY F. MATHER.

Abundant evidence of two distinct Glacial epochs has been reported by several investigators from various mountain ranges in the western portion of the continent. During the past season glacial deposits have been examined and mapped about the margin of the San Juan Mountains, which deposits have been interpreted to indicate an epoch of glaciation distinct from the two later epochs that have been clearly recognized in the history of the range.

For convenience, the three distinct epochs are referred to, beginning with the oldest as "San Juan," "Big Horn" and "Uinta."

The composition, distribution and topographic relations of the San Juan glacial drift indicate that this earliest known epoch was separated from the Big Horn Glacial epoch by a much longer time than the Big Horn was separated from the Uinta. The two later epochs appear to have been separated by a much longer time than has elapsed since the last disappearance of glacial ice from the range. The San Juan Glacial epoch is so far removed from the present time that the glacial deposits of that epoch are found at but a few places, where conditions were most favorable for their preservation.

There are reasons for believing that the San Juan Glacial epoch may have been characterized by small ice caps among the western ranges rather than by Alpine glaciers, which were the prevailing type during the Big Horn and Uinta epochs.

There are good reasons for believing that the San Juan epoch preceded the development of the great canyons among the mountains, and, therefore, that much of the sculpturing which has given form to the scenic features of the range is inter- and post-Glacial in origin. The time relation of the epochs of glaciation to other events in the physiographic history of the range were also suggested.

The paper was discussed by H. E. Gregory.

Glacial Investigations in Minnesota in 1911: FRANK LEVERETT.

A sheet of old calcareous drift deposited by an ice sheet radiating from central Canada covers nearly all of Minnesota and extends into western Wisconsin. The prominent moraines of western Minnesota, named by Upham, Itasca, Leaf Hills and Fergus Falls, were formed in the order named, as is shown by the glacial drainage from them. The rock constituents of these moraines show remarkable disintegration that suggests a possible pre-Wisconsin age. After these moraines were formed by the ice radiating from central Canada, there followed an ice movement radiating from the high tableland northeast of Rainy Lake. This moved across the northern ends of the above-named moraines and extended a few miles beyond the portion of the Mississippi above St. Paul. This produced the so-called "red drift." After this ice movement waned there followed a re-advance of the ice sheet radiating from central Canada which had its main axial movement through the Red-Minnesota-Des Moines Valley; but which also extended southeastward across the portion of the Mesabi Range west from Hibbing, Minnesota, and spread to the left and right in a basin which divides its drainage between the St. Louis and Mississippi Rivers. This ice movement deposited the so-called "gray drift" of the Minnesota Reports. It forms only a thin veneer on the portions of the Leaf Hills and Fergus Falls moraines which it overrode, and it failed to cover all of the Leaf Hills moraine. The correlative position of the Lake Superior Lobe is found to have been but little beyond the western end of the present lake, in Carleton County, Minnesota. A large glacial drainage line opened a great valley along the St. Louis between Floodwood and Carleton, but was there turned southwestward because of the presence of the Superior Lobe. The relations of this latest ice movement from central Canada to the Glacial Lake Agassiz are such as to make necessary a radically different interpretation from that given by Upham in his monograph on Lake Agassiz.

The paper was discussed by Lawrence Martin and J. B. Tyrrell.

Recent Studies of the Moraines of Ontario and Western New York: FRANK B. TAYLOR.

The paper was entirely descriptive of moraines recently mapped in the areas of Ontario and western New York.

Remarks were made by W. M. Davis and H. L. Fairchild.

A Grooved and Striated Contact Plane between the Nebraskan and Kansan Drifts: J. Ernest Carman. (Introduced by George F. Kay.)

The paper described the unique feature of a grooved and striated contact plane between the Nebraskan (pre-Kansan) and Kansan drifts. Both sides of the contact plane are striated. Neither side is the mold of the other. The possible explanations are considered and the conclusion reached that glaciation produced the feature.

The Nebraskan Drift of the Little Sioux Valley in Northwest Iowa: J. Ernest Carman. (Introduced by George F. Kay.)

The paper traced a farther extension of the Nebraskan drift and compared the Nebraskan and Aftonian deposits of this region with those along the Missouri River.

Dr. Carman's two papers were discussed by J. W. Spencer, F. Leverett and W. M. Davis.

Hanging Valleys and their pre-Glacial Equivalents in New York: J. W. Spencer.

Visiting that most beautiful gorge, Watkins Glen, at the head of Seneca Lake, it would seem that the stream is entirely post-Glacial; but above the railway bridge a great cove, like that of the Whirlpool Basin at Niagara, is developed, with its northern side and end composed of drift. Its continuing channel to the lake has been discovered by boring. The same is true of other falls in this locality. Taughannock, on the western side of Cayuga Lake, is of little less importance. Its pre-Glacial channel, as observed by Hall in 1842, is situated immediately to the north.

Equally important are hanging valleys in northern New York. Between Carthage and Boonville is a plateau at 1,400 feet above sea level, overlooking the Black River and the much lower country east of it. The plain is bounded on the west by an escarpment 500 feet high, surmounted by another plateau. The Black River shales here are easily incised. Here the finest hanging valley with waterfalls is Whetstone Gulf, two miles north of Housie P. O., while the great pre-Glacial valley occurs at this hamlet, with the drift partly removed from it.

It seems that wherever an important drainage basin occurs with modern waterfalls, equivalent pre-Glacial valleys may be found, although more or less filled with drift. Accordingly, in New York State hanging valleys of themselves are no evidence whatsoever of the over-deepening of the trunk valleys or plains in front of them by glacial erosion.

Closing Phase of Glaciation in New York: H. L. Fairchild.

As the Labradorian ice sheet melted away from the north border of New York State, it allowed the water of the ice-bound Lake Iroquois to escape at Covey Hill Gulf and to pass around the northeast slope of the Adirondack highland. Being confined and directed by the ice border, this stream flow produced the extensive areas of bare rock in the towns of Mooers, Altona and Beekmantown, formerly described by Woodworth (N. Y. State Museum Bulls., 83, 84). The later stream flow, along the Altona rocks, determined the level of a narrow lake lying northwestward, into which Lake Iroquois was lowered by the waning of the ice front on Covey Hill, and for a time this lake succeeded Iroquois in the Ontario basin. It is proposed to call this water Lake Emmons (after Ebenezer Emmons, whose district in the first geologic survey of the state covered this area). The further weakening of the ice border finally allowed Lake Vermont (named by Woodworth), which had previously been confined to the Champlain Valley, to succeed Lake Emmons and in turn to occupy the Ontario basin. It is proposed to call this expanded water Lake Vermont-New York. These two water planes in the Ontario basin, inferior to Iroquois, are represented chiefly by delta sand-plains on the larger streams. Eventually the waning of the ice east of the Champlain embayment allowed the glacial waters to become confluent with the sea, and the sea level waters were thus established in both the Champlain and Ontario basins at the same time. The height of the marine beaches about Covey Hill is 525 feet, which definitely gives the amount of land uplift on the international boundary since the ocean transgressed that area. Maps exhibit the glacial drainage channels, the deltas and the shore lines of the three water planes in the Champlain district and the four planes in the Ontario district.

The paper was discussed by F. B. Taylor, J. W. Spencer and H. L. Fairchild.

Post-Glacial Erosion and Oxidation: George Frederick Wright.

(1) Opportunities for observation in Ohio. (2) Small amount of erosion by the streams north of the watershed entering Lake Erie. (3) Esker terraces in the valleys of the Styx and Killbuck on the south side of the watershed. (4) Comparison of calculations from these sources with those from Niagara and other post-Glacial gorges. (5) Ex-

tent of pre-Glacial oxidation. (6) Evidence of small amount of oxidation since the Wisconsin epoch. (7) Evidence that the till of the earlier Glacial epoch consists largely of material oxidized during pre-Glacial times. (8) Evidence of unoxidized material mingled with the highly oxidized material of the earlier epoch. (9) Evidence indicates that the date of the Wisconsin epoch is to be reckoned by thousands, rather than by tens of thousands of years, and the earlier epochs by tens of thousands rather than by hundreds of thousands of years.

The paper was discussed by F. Leverett, J. W. Spencer, H. L. Fairchild and the author.

The Intermingling of Pleistocene Formations: B. Shimek.

The paper discussed the effect produced by ice-sheets passing over older Pleistocene formations. Special illustrations are found in the mingling of fossiliferous loess and Wisconsin drift at Des Moines, Iowa, fossiliferous silts at Sioux Falls, S. D., and in other places.

Loess a Lithological Term: B. Shimek.

The term "loess" has commonly been understood as implying a more or less distinct division of time. The fact is set forth that there are several loesses deposited at different periods and that loess does not designate a distinct period of time, but indicates rather a condition of deposition, as do such terms as "sandstone," "limestone" and "drift."

Professor Shimek's two papers were discussed by W. C. Alden, F. V. Emerson, Frank Leverett, G. F. Wright and the author.

Criteria for the Recognition of Ancient Delta Deposits: Joseph Barrell.

Previous to the discussion of criteria, definitions were given and an analysis of the parts of a delta. The criteria naturally are different for each part. Variations in the proportions of the parts, the ratios in which these may enter into ancient formations and the intergradations of parts were next considered. Where the conditions of delta growth were such as to give gradations between parts, the criteria become overlapped and tend to result in confusion. It is concluded that deltas of previous geologic ages have commonly developed under quite different conditions from those taken as typical in modern deltas. The principle of a delta cycle is next developed, showing the theoretic stages of rivers building outward and upward against the sea, followed in a later stage by marine dominance and plantation. Where the larger features of an ancient deposit are known, the principle of the delta cycle may be of value as a criterion of origin. Illustration is made by application to the late Mesozoic formations of the Atlantic Coastal Plain. The evaluation of stratigraphic criteria is next taken up with the view first of separating the subaerial delta beds—those periodically exposed to the air, from the subaqueous—those permanently covered with water. Secondly, however, the criteria record also physiographic and climatic conditions controlling the character of the beds. The stratigraphic criteria are taken up in order, and the degree of significance attaching to each is discussed. Two chief conclusions are reached. First, the need of extended study of the stratigraphic characters of present sedimentation. Second, most individual criteria are to some degree indeterminate and a conclusion in regard to the mode of origin of a formation or part of a formation should, in order to obtain acceptance, be based on the convergence of several lines of evidence.

Stratigraphic and Paleontologic Features of Ancient Delta Deposits: A. W. Grabau.

After a brief reference to the pre-Cambric or early Cambric delta fan of the Pacific Province and the Torridon of Scotland, the author discussed the late Ordovicic and early Siluric fans of the Appalachian region, the Schawangunk dry delta fan and its relationship to the Salina desert, the Esopus delta and its relation to the Oriskany deposits, the Early Devonic talus breccia of Michigan and western Ontario, the Old Red of Scotland and the Catskill group, the Pocono, Mauch Chunk and Pottsville and the Triassic fans of America and western Europe, with special reference to their stratigraphic and paleontologic characters and their bearing on paleogeography.

A Mississippian Delta in the Northern New River District of Virginia: E. B. Branson.

A delta started in the Devonian in the New River district and continued through most of the Mississippian. The thickness of the Mississippian part is more than 5,000 feet and consists of varicolored shales and sandstones that thin out in all directions excepting southeast from this region. The Mississippian rocks are known as the Pulaski formation and are to be correlated with the Pulaski, Greenbrier, Bluefield and Hinton formations fifteen miles farther north.

Discussion of the last three papers was participated in by J. M. Clarke, David White, G. W.

Stose, A. Keith, G. I. Adams, E. T. Wherry, H. B. Kümmel and W. C. Alden, with replies by Joseph Barrell and A. W. Grabau.

Differential Erosion and Equiplanation in Portions of Yukon and Alaska: DeLorne D. Cairnes. (Introduced by Percy E. Raymond.)

Certain limestones and dolomites have been found to offer much greater resistance to ordinary sub-aerial erosive agencies than most other types of sediments, although many of these may be considerably harder and apparently better adapted to withstand the destructive forces to which rocks are exposed. In portions of the Yukon plateau province, the original peneplanated upland surface has been almost entirely destroyed in areas in which the bed rock is chiefly highly metamorphosed slate and quartzite, but is well preserved in adjoining tracts where limestones and dolomites predominate.

Where remnants of the original plateau-surface remain, agencies, including nivation, frost and chemical action are at work on the upland tending to remove all inequalities of the surface by transporting material from the upper to the adjoining lower levels; for this process the term "equiplanation" is proposed. This name has suggested itself as its results tend to make the elevation of all points equal in the area affected. Equiplanation is the reverse of peneplanation, as by isoplanation there is but a slight if any loss of material within the planated areas, but in peneplanated tracts all crustal matter above sea-level tends to become transported to the ocean. Equiplanation thus includes all planating activities, even wind action, whereby a plain-like surface tends to be produced, and by which there is no perceptible loss of material to the planated tract; all ordinary stream action, which is the main factor in peneplanation, is thus excluded.

The paper was discussed by W. W. Atwood, W. M. Davis, H. M. Eakin and the author.

The Cenozoic History of the Wind River Mountains, Wyoming: L. G. Westgate and E. B. Branson.

A preliminary account of the successive peneplanes, partial peneplanes and terraces of the southern part of the Wind River Mountains, the pre-Glacial gravels capping some of the terraces and the relation of the terraces to deposits of an earlier and a later glaciation.

The Stability of the Atlantic Coast: Douglas Wilson Johnson.

The results of the Shaler Memorial investigation of shoreline changes along the Atlantic coast indicate that there has been no appreciable subsidence of this coast within the last few thousand years. The phenomena which seem to indicate recent subsidence appear to fall into three groups: (1) Fictitious appearances of subsidence which are produced by wave action on a retrograding shore line without any change in the level of land or sea; to this group belong many instances of submerged stumps, peat exposed at low water on the seaward side of barrier beaches, erect trees recently killed by the invasion of salt water, etc. (2) Phenomena produced by a local rise in the high tide surface, due to a local change in the form of the shoreline, unaccompanied by any general change in the relative level of land and sea; in this group may be found examples of practically all phenomena ordinarily attributed to a recent subsidence of the land. (3) Phenomena produced by an actual subsidence of the land or rise of the sea level which occurred some thousands of years ago; in this group belong many of the deeply buried peat deposits and submerged stumps. The evidence of coastal stability consists of (1) the form and position of successive beach ridges the oldest of which were built by the waves thousands of years ago, yet later than the deeply buried peat deposits; (2) the position of abandoned marine cliffs on which the waves can not have worked in recent time; and (3) the absence of a fringe of dead trees on those portions of the coast which are exposed neither to direct wave attack nor to local fluctuations of the high tide surface. It is concluded, with reference to the Atlantic coast, that the land can not have subsided as much as a foot within the last century; that there can have been no long-continued progressive subsidence at so high a rate as one foot per century, within the last few thousand years; and that no evidence thus far available can be regarded as satisfactory proof of any degree of recent subsidence, either spasmodic or progressive.

The paper was discussed by C. A. Davis, H. B. Kümmel, J. W. Spencer and A. C. Lane.

Physiography of the East African Plateau: George L. Collie.

Four physiographic regions may be recognized in British East Africa. First, the coastal plain; second, the foot plateau; third, the gneiss plateau; fourth, the lava plateau, which includes within its boundaries the great Rift Valley. The coastal plain is generally but two or three miles wide. It is composed of recent coral rock, and it is a true degradation plain; the agent is probably marine

erosion. Rising rather abruptly from the coastal plain is the great plateau which extends to the basin of Victoria Nyanza. The frontal portion, called by Gregory the foot plateau, is underlain by sedimentaries of Mesozoic age. The main portion of the plateau is gneiss, but toward its western border there have been great extravasations of lava, which have completely covered the original gneiss surfaces over a belt 100 miles wide and extending north and south indefinitely. The lava flows are connected with the rifting processes that have formed the rift valley. The underlying rocks have some bearing upon the minor features of the different regions, but this is a matter of detail. The plateau as a whole from ocean to the Victoria Nyanza basin should be considered as a unit in its larger aspects. The plateau is a very ancient feature; it has been thoroughly peneplaned, though great residual masses of gneiss remain, especially in the region between Voi and Kiu. These mound rocks in some cases rise to the dignity of mountain ranges. The most remarkable feature of the plateau is the constant, uniform rise of the peneplaned surface from sea level to a height of nearly 10,000 feet at the Man or western escarpment of the Rift Valley. The plateau surface is really a great beveled slope which rises on the average about 20 feet to the mile for 500 miles. The plateau is typical of those that lie in the monsoon region, in that only the higher portions and those that lie near sea level are being acted upon by normal erosion. The intermediate and by far the greater area is being degraded by deflation and sheet-flood erosion, chiefly. There are two brief and widely separated rainy seasons. The conditions are such that, in the main, there is a large intake of ground water and relatively little run off, and hence very little dissection. In the interim between rainy seasons the ground becomes parched and dry, so that deflation becomes of importance and offsets dissection. The plateau confirms the truth of observations made in South Africa and elsewhere that one type of peneplanation may go on at any altitude above sea level. This type of peneplanation does not require desert conditions, as is sometimes said. Thirty inches of water fall annually over much of this plateau, but it does not require monsoon conditions where rainfall is concentrated in widely separated rainy seasons with arid or semi-arid conditions in between.

On the Nomenclature of Faults: HARRY FIELDING REID.

This was a preliminary report by the chairman of the committee appointed by the society at the Baltimore meeting (1908) and was submitted for discussion and criticism in advance of making a final report at the next meeting of the society.

Boulder Beds of the Caney Shale at Talahina, Oklahoma: J. B. WOODWORTH.

The Caney shales of Mississippian age in southeastern Oklahoma carry grooved and striated stones and large boulders, all of which phenomena have been described by Mr. J. A. Taff, of the Geological Survey. The writer describes the best known locality near Talahina, Okla., and ascribes the markings on the stones and boulders to internal rock movements accompanying the faulting of the beds. It is thought with Mr. Taff that the distribution of the boulders, aside from the nature of their striated surfaces, demands transportation by ice. Other evidence is briefly cited in support of the idea that the Permian Glacial period was preceded by signs of widely distributed ice action of one kind or another in the Carboniferous period in the northern hemisphere.

Some Coastal Marshes South of Cape Cod: CHARLES A. DAVIS.

A report on a continuation of the work on salt marshes in the vicinity of Boston, the results of which were reported at the Boston meeting of 1909. The structure of salt and brackish marshes on the south side of Cape Cod and on Long Island was described and the bearing of this on the problem of recent coastal subsidence was discussed.

The paper was discussed by J. B. Woodworth, A. W. Grabau and the author.

Structure of the Helderberg Front: A. W. GRABAU.

The Helderberg Front is the northern extension of the westernmost belt of the Appalachian folded area, left after extensive erosion. The former extent east of the Hudson is partly indicated by Becraft Mountain and Mt. Ida. The basal part is of folded Hudson strata unconformably succeeded by late Siluric showing various phases of overlap. The Appalachian folds are of the usual asymmetric type, while the range from near Rosendale to Catskill and beyond is complicated by one or more pronounced overthrusts. The first of these was described by the author from Kingston and subsequently more fully discussed by Van Ingen and Clark. Chadwick has described a part of the thrust at Saugerties, and the author has determined its character near Catskill. Several new sections from this last region were presented.

The paper was discussed by J. B. Woodworth.

Some Relations between Gravity Anomalies and the Geologic Formation in the United States: WILLIAM BOWIE. (Introduced by A. H. Brooks.)

A report of an investigation of topography and its isostatic compensation upon the intensity of gravity will soon appear as a Coast and Geodetic publication. This and a subsequent investigation, involving 124 gravity stations, show the gravity anomalies in the United States are very small as a rule and that there is no apparent relation between the size and sign of the anomalies and the character of the topography. There is, however, a relation between the sign of the anomalies and the geologic formation. The stations in the older formations tend to have anomalies of the positive sign, indicating an excess of mass, and the stations in the most recent formations tend to have anomalies with the negative sign. It is probable that the anomalies are caused by erroneous assumptions regarding the surface density of the material at a station, and to a departure of the crust of the earth near the station from a state of complete isostatic compensation.

The paper was discussed by H. F. Reid and the author.

The following papers were presented by title:

Geological Reconnaissance in Northeastern Nicaragua: OSCAR H. HERSHEY.

The Geology of Steep Rock Lake: ANDREW C. LAWSON.

The Mesozoic Stratigraphy of Alaska: G. C. MARTIN.

Color Scheme for Crystal Models: GEORGE H. CHADWICK.

Occurrence of Petroleum Associated with Faults and Dikes: FREDERICK G. CLAPP.

New Minerals from the Favas of Brazil: OLIVER C. FARRINGTON.

Progress of Opinion as to the Origin of the Iron Ores of the Lake Superior Region: N. H. WINCHELL.

Saponite, Thalite, Greenalite and Greenstone: N. H. WINCHELL.

Pre-Wisconsin Channels in Southeastern South Dakota and Northeastern Nebraska: J. E. TODD.

Geographic Cycle in an Arid Climate: Should its Development be by Wind or Water? CHARLES R. KEYES.

The Effect of Rapid Off-shore Deepening on Lake Shore Deposits: RUFUS MATHER BAGG, JR.

List of Underground Temperatures in the United States: N. H. DARTON.

A Bibliography of the Mammoth Cave: HORACE C. HOVEY and R. ELLSWORTH CALL.

The following officers were elected for 1912:

President—Herman LeRoy Fairchild, Rochester, N. Y.

First Vice-president—Israel C. White, Morgantown, W. Va.

Second Vice-president—David White, Washington, D. C.

Secretary—Edmund Otis Hovey, New York, N. Y.

Treasurer—William Bullock Clark, Baltimore, Md.

Editor—J. Stanley-Brown, Cold Spring Harbor, N. Y.

Librarian—H. P. Cushing, Cleveland, Ohio.

Councilors (1912–14)—S. W. Beyer, Ames, Iowa, and Arthur Keith, Washington, D. C.

Fellows elected December 28, 1911: R. C. Allen, Robert Van Vleck Anderson, Manley Benson Baker, Edwin Bayer Branson, Durdon Montague Butler, Stephen Reid Capps, Jr., George Halcott Chadwick, Clarence Norman Fenner, James H. Gardner, Walter Granger, John Sharshall Grasty, William Otis Hotchkiss, Cyril Workman Knight, Adolph Knopf, Lawrence Morris Lambe, Elwood S. Moore, Daniel Webster Ohern, Sidney Paige, Joseph E. Pogue, William Frederick Prouty, Elmer S. Riggs, Jesse Perry Rowe, John Joseph Rutledge, Joseph Theophilus Singewald, Jr., Burnett Smith, Frank Springer, Clinton Raymond Stauffer, Lloyd William Stephenson and Mayville William Twitchell.

Wednesday evening the Geological Society of America joined with other affiliated societies and the general American Association for the Advancement of Science in listening to the address of welcome by President Taft. Thursday afternoon was devoted to visiting the Geophysical Laboratory of the Carnegie Institution, while the evening was occupied with the annual dinner of the society followed by much speech making under the leadership of Dr. J. M. Clarke, of Albany, N. Y. On Friday evening, the presidential address of Professor Davis was followed by a smoker at the Cosmos Club tendered by the Geological Society of Washington to the Geological Society of America, the Paleontological Society and the Association of American Geographers.

The next meeting of the society will be held at Yale University, New Haven, Conn., a year hence.

EDMUND OTIS HOVEY,
Secretary